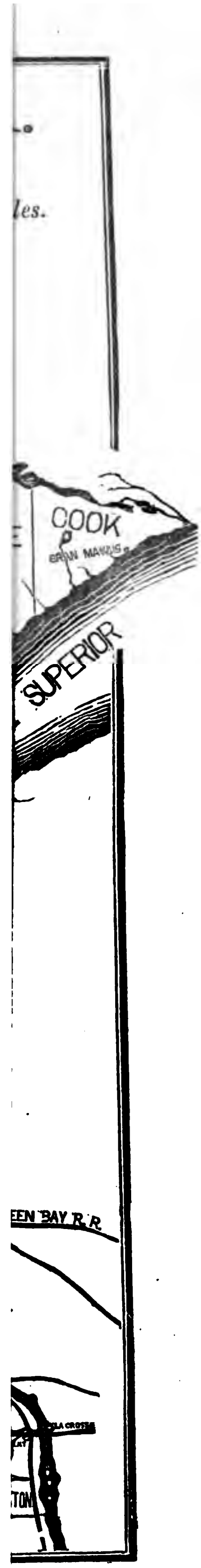
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# THE GEOLOGICAL

AND

# NATURAL HISTORY SURVEY

OF

# MINNESOTA.

## THE EIGHTH ANNUAL REPORT,

FOR THE YEAR 1879.

Submitted to the President of the University, Feb. 18, 1880

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1880.

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PUBLICATIONS OF THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.

ANNUAL REPORTS.

*The First Annual Report on the Geological and Natural History Survey of Minnesota, for the year* 1872. *By N. H. Winchell.* 8*vo.* 112 *pp., with a colored geological map of the State. Published in the Regents' Report for* 1872. *Out of print.*

*The Second Annual Report on the Geological and Natural History Survey of the State, for the year* 1873. *By N. H. Winchell and S. F. Peckham. Regents' Report;* 148 *pp.* 8*vo.; with illustrations.*

*The Third Annual Report on the Geological and Natural History Survey of Minnesota, for the year* 1874. *By N. H. Winchell.* 41 *pp.* 8*vo., with two county maps. Published in the Regents' Report for* 1874.

*The Fourth Annual Report on the Geological and Natural History Survey of Minnesota, for the year* 1875. *By N. H. Winchell, assisted by M. W. Harrington.* 162 *pp.* 8*vo.; with four county maps and a number of other illustrations. Also published in the Regents' Report for* 1875.

*The Fifth Annual Report on the Geological and Nataral History Survey of Minnesota, for the year* 1876. *By N. H. Winchell; with Reports on Chemistry by S. F. Peckham, Ornithology by P. L. Hatch, Entomology by Allen Whitman, and on Fungi by A. E. Johnson:* 8*vo.* 248 *pp.; four colored maps and severa other illustrations. Also published in the Regents' Report for* 1876.

*The Sixth Annual Report on the Geological and Natural History Survey, for the year* 1877. *By N. H. Winchell, with Reports on Chemical Analyses by Prof. Peckham, on Ornithology by P. L. Hatch, on Entomology by Allen Whitman, and on the Geology of Rice County by L. B. Sperry; three geological maps and several other illustrations.* 226 *pp.* 8 *vo. Also published in the Regents' Report for* 1877.

*The Seventh Annual Report on the Geological and Natural History Survey of Minnesota, for the year* 1878. *By N. H. Winchell, with a Field Report by C. W. Hall, chemical Analyses by S. F. Peckham, Ornithology by P. L. Hatch, a List of the Plants of the north shore of Lake Superior by B. Juni, and an Appendix by C. L. Herrick on the Microscopic Entomostraca of Minnesota, with twenty-one plates.* 123 *pp.* 8*vo. Also published in the Regents' Report for* 1878.

MISCELLANEOUS PUBLICATIONS.

1. CIRCULAR NO. 1. *A copy of the law ordering the survey, and a note asking co-operation by citizens and others.* 1872.

2. PEAT FOR DOMESTIC FUEL, 1874. *Edited by S. F. Peckham.*

3. REPORT ON THE SALT SPRING LANDS DUE THE STATE OF MINNESOTA. *A history of all official transactions relating to them, and a statement of their amount and location.* 1874. *By N. H. Winchell.*

4. A CATALOGUE OF THE PLANTS OF MINNESOTA; *prepared in* 1865 *by Dr. I. A. Lapham, contributed to the Geological and Natural History Survey of Minnesota, and published by the State Horticultural Society in* 1875.

5. CIRCULAR NO. 2. *Relating to Botany, and giving general directions for collecting information on the flora of the State.* 1876.

6. CIRCULAR NO. 3. *The establishment and organization of the Museum.* 1877.

7. CIRCULAR NO. 4. *Relating to duplicates in the Museum and exchanges.* 1878.

# ADDRESS.

THE UNIVERSITY OF MINNESOTA,
Feb. 18, 1880.

*To the President of the University:*

DEAR SIR—I herewith transmit the Eighth Report on the progress of the Geological and Natural History Survey of the State.

Very respectfully your obedient servant,

N. H. WINCHELL.

# REPORT.

## I.

## SUMMARY STATEMENT.

The season's work was begun by the detailed examination of Goodhue county, and of a portion of Wabasha—occupying about six weeks. The field-work was then transferred to the northern part of the State, where a special survey was made of the valley of the St. Louis River from Fond du Lac to about three miles above Knife Falls, covering the region of the *Dalles* and the water-power of that stream, and extended to some of the contiguous country. It was in July and August that another visit was made to the various points on the Lake Superior shore, that were shown by the examinations of the preceding summer to possess special interest, between Duluth and Pigeon River. Many extra specimens were obtained, and additional observations were made. A number of photographs were obtained of points exhibiting peculiar or typical geological features. This trip was extended to Silver Islet and Isle Royale in the small boat belonging to the survey, for the purposes of comparative study and the gathering of specimens. In the fall two inland expeditions were made from Grand Marais,—one occupying about ten days, and the other about six weeks. These, with the interior explorations of last year, so far as they covered that part of the State, may be said to carry the surveyed area in the northeast part of the State as far west as to Poplar river, though there are some points on the upper waters of the Cascade river that will still have to be examined, lying east of the Poplar river, while also a considerable area west of the Poplar river has been examined sufficiently.

In addition to the foregoing, which has been the personal labor of the writer in the field, the survey has made steady—and in some cases rapid—progress in other directions during the year. Mr. Warren Upham, late of the New Hampshire Geological Sur-

vey, has been occupied nearly the whole season in studying the geology of the drift-covered counties in the central and western portions of the State, with special reference to the topography, glacial geology, and economic resources of those counties. With a horse and wagon he has traveled about 3,300 miles, and has in his note-books the necessary data for reporting in full on twenty-two counties, or an area of over sixteen thousand square miles.

Prof. C. W. Hall spent the summer vacation in making collections of animals and plants on the Minnesota shores of Lake Superior, in company with Mr. Thomas Roberts, a student of the University. A catalogue of species of birds noted by Mr. Roberts accompanies this report. This catalogue will be extended to cover species collected since the beginning of the survey, as opportunies have arisen.

Mr. C. L. Herrick has been mainly unengaged during the year, but in the fall he aided Mr. Hall in sundry work connected with the Museum.

Prof. Peckham's report on the analysis of iron ores from different points in the State accompanies this report, and Dr. P. L. Hatch makes an annual statement of progress in the ornithological section.

At different times during the season the field parties of the survey have been accompanied and aided by the following gentlemen, viz.: Prof. H. B. Wilson, of Red Wing; Prof. George Weitbrecht, St. Paul; Rev. C. M. Terry, Minneapolis; Prof. Jabez Brooks, of the University of Minnesota; and Messrs. A. P. and D. D. Brooks, students in the University.

A report on operations in the Museum accompanies this, giving a list of recorded additions to the specimens, and the exchange of duplicates.

The survey has again to acknowledge the generosity and courtesy of President John P. Ilsley, of the St. Paul and Duluth R. R., and Supt. Chas. F. Hatch, of the Minneapolis and St. Louis R. R., for free transportation on those roads respectively, for the various members of the survey, and to the Mayhew Brothers, of Grand Marais, for the use of a building for the headquarters of the different parties of the survey while at work in that part of the State.

The editions of the first, second and third annual reports of the survey have been for some years exhausted. They were very small. With the publication of the fourth report the edition was increased by act of the Legislature to 1,000 extra copies. There

are frequent inquiries for the first, second, and third reports by citizens of the State, and by parties from abroad. These requests cannot be complied with, but, so far as possible, all reasonable demands for the reports are supplied. With the continuation of the survey, and the publication of its results, the demand for the earlier reports constantly increases. It is suggested that the first three reports might be reprinted in one volume. The three reports together contain 300 pages.

# II.

# LITHOLOGY.

The State of Minnesota possesses the widest range of lithological features. Its rocks show nearly all the mineral changes that have characterized the strata of the crust of the earth, and nearly all the crystalline and non-crystalline conditions and variations (excepting the post cretaceous trachytes) that are to be found in the United States. Owing to this great range in their natural history, the study of the strata becomes one of great interest and value. This is true both in an economical sense and in a scienfic point of view. The mineral associations which are known to accompany the existence of the useful and precious metals, the importance of their complete elucidation by the most exact methods, and the need that these examinations shall supplement the field observations, alike demand of the survey the full and searching scrutiny which modern science can give, and which alone will subserve completely the object for which the survey was instituted.

A large amount of field observations have been made, and many specimens have been gathered, the outward appearances of the formations have been carefully noted down in the field books, and annual reports of progress have dealt largely with these outward aspects. In view of the contemplated publication of the final volumes of the survey, it becomes necessary to devote a portion of the time available to the laboratory work necessary for these nicer investigations. The fossils of the sedimentary formations, the Silurian, Devonian and Cretaceous, must be named and catalogued, and the mineral composition of our crystalline rocks in the nothern part of the State must be ascertained. The methods of paleontological study are familiar to the geologists of the United States, and are well known to the people by the publication of numerous fine volumes by the State Governments, and by the United States; but the determination of the crystalline composition of the older, non-fossiliferous rocks, by the most exact and the most direct methods, is a science which is of recent birth.

The provisional determination of the minerals constituting a rock in the field, by the use of the pen-knife and the pocket lens, is often found to be erroneous when they are subjected to more careful examination. Indeed the minuteness of the various grains is often such that they cannot be separated from the mass even for individual chemical analysis, or blow-pipe examination. The only recourse was to perform an analysis of the rock in mass. This gives the aggregate amount of the various elements, as calcium, aluminum, iron, etc., but the manner in which these are combined, or what minerals they form, is still wholly conjectural. It is to the microscope we are indebted for the means of ascertaining the mineral composition of rocks, however fine, or to whatsoever extent they may have been changed by natural causes. Indeed, great changes in the rocky structure of the earth, long discussed with vague uncertainty, are fully explained by the microscopic phenomena of their mineral contents. It is proposed to give a brief resume of the methods of microscopic lithology, as an introduction to the results of the work that is now being carried on in the laboratory of the survey, and for preparing the way to the more advanced statements of the final report. These methods are applicable especially to the crystalline rocks—such as, having been once in a sedimentary condition, have been heated, pressed, dissolved, and then recompounded by crystallization, according to the laws of chemical affinity into mineral species, such as the feldspars or hornblendes. They apply with special value to the rocks known as Igneous, as these, on cooling from a molten condition always crystallize, unless the process be sudden, when they take on the glassy state or become amorphous slags. A large part of the State of Minnesota is occupied by rocks of this kind, while a still larger part is occupied by strata, which, although not igneous, are yet in that perfectly crystalline condition that shows they have been metamorphosed from a former sedimentary condition, and the distribution of the various elements composing them has been wholly remodeled since their formation.

The apparatus necessary for the microscopic examination of crystalline rocks is quite simple. Any method can be pursued to grind a fragment of the rock to be examined to a thin slice; so thin that light easily passes through it. It may be done wholly by hand, but in the laboratory of the survey is one of Prof. A. A. Julien's "lithologist's lathes," which is quite similar to a lapidary's, having leaden and iron laps, rotating horizontally on which the fragment is to be held by the fingers and ground with coarse

emery and water. The city water works of Minneapolis carry a pressure into the University which has an average of about twenty-five pounds, and this pressure is used to run the lathe by the use of one of Tuerk's hydraulic motors. The fragment is first ground to a smooth and even surface on one side by holding it with the fingers on the rotating leaden lap with moderately coarse emery and water. It is then changed to the iron lap, with fine emery powder for smoothing the same surface: and lastly, is polished by hand with "emery shine" on a piece of plate glass. This smoothed surface is then washed entirely clean and is firmly cemented by Canada balsam to a small piece of plate glass about an inch and a half square. The process of attaching it to the glass plate is performed by gently warming and melting a little hard Canada balsam lying on the glass plate over a spirit lamp. In order that all smoke may be kept from the plate, and that the glass may heat evenly, it is laid on a thin iron plate, which is held or supported by tripod, over the lamp. When the balsam is thoroughly liquified, without boiling, the smoothed surface of the ground fragment (itself also warmed by lying on the iron plate) is pressed into the balsam and firmly held down on the glass till the balsam cools and hardens. No bubbles of air must be allowed to remain between the fragment and the glass plate. The other side of the fragment is now applied to the leaden lap and ground, as before, till it is thin enough to begin to transmit light, when it is finished by grinding with the fine emery on the iron lap, and rendered perfectly smooth with the emery shine by careful rubbing by hand on the glass plate. When it is finished it is so thin that it is wholly transparent, and its edge, lying on the glass plate, is hardly visible to the eye. The piece of plate glass, after thorough washing and drying, is again warmed on the iron plate, with a small fragment of hard balsam lying on the section. At the same time another fragment of hard balsam is warmed in the same way, and melted on a common microscopic glass slide, the best size of which is 45x25 mm. When the thin section is loosened by the melting of the balsam, and the fragment lying on it is liquified, a thin glass cover is placed on the section, and the section and cover, adhering together, are gently pushed off the glass plate on to the liquid balsam lying on the warmed glass slide in such a way that the section shall be embraced between the slide and the cover. By gently moving the cover, and pressing it down, all air bubbles are excluded, and it is brought as nearly in contact with the slide as is possible, with the thin section near the center of the slide. When it is sufficiently cooled,

and the balsam is hardened, the superfluous balsam is removed with a warmed pen-knife, or dissolved away with a drop of alcohol. The thin section, when cleaned again and wiped dry with a cloth, is ready for examination.

The microscope necessary for this use is not yet made in this country. Several styles are made in Europe, particularly the stauroscopic microscope of Rosenbusch, and that of Watson, recommended by Mr. Rutley in his recent work, "The Study of Rocks," published in London. But a common microscope of any style can be easily changed, and the necessary attachments furnished, in this country. The Tolles microscope, belonging to the survey, was altered in New York by Prof. A. A. Julien, and by his direction was supplied with the necessary accessories. The stage must rotate on an axis which is the same as the line of vision through the body of the microscope, and the edge of the rotating stage must have a graduated scale for determining the degrees of rotation. Below the stage is placed a Nicol prism for polarizing the ray of light that enters the microscope, and above the ocular is another for analyzing it on its emission. These are both provided with graduated rims, so that on their rotation the degrees of change can be quickly read off. They are each also easily removable. In the eye-piece (A) are crossed spider-lines, so that the planes of vibration of the polarized light can be accurately adjusted in relation to any angle, or any line of a crystal that may be placed on the stage. It is also necessary to have an accurate "centering" instrument, *i. e.*, a nose-piece, adjustable in the lower end of the tube of the microscope, by which the line of vision in the center of the field can be made to coincide exactly with the axis of revolution of the stage. Mr. Rosenbusch's microscope has centering screws that move the body of the microscope itself.

As minerals are produced by the combination of the elements (as iron, silicon, calcium) so the crystalline rocks are produced by the combination of minerals. The elements, however, combine with mathematical precision, and in accordance with definite chemical affinities, but the compounding of the minerals with each other to constitute the crystalline rocks, is very various and heterogeneous. A mineral species is definitely known and describable, but the rock compounds shade into each other, and can be subjected to only a general and broad system of nomenclature.

The geometrical forms of crystals are so constant, that all minerals having a crystalline structure are referable to some of the six systems of mineralogy. These are fully described and illus-

trated in the usual text-books and manuals of Mineralogy, of which the chief in the English language, perhaps, are those of Dana.* These systems are as follows :—

ISOMETRIC.
TETRAGONAL.
HEXAGONAL.
ORTHORHOMBIC.
MONOCLINIC.
TRICLINIC.

These have different optical characters in polarized light. *Amorphous*, or non-crystalline substances, like glass, do not polarize light, nor affect its nature after polarization. They simply refract it, or divert it from its original direction. The interior particles of crystals are arranged in lines and planes, having fixed relations to the axes of the crystals, and when a ray of light enters among these particles it is propagated, or interrupted, or modified, according to the ease with which its waves can move among these planes, and hence emerges a *polarized* ray. The simple polarization of light does not affect its appearance to the eye, except to dim its brightness. Hence when the polarizer only, which consists of a piece of a crystal of Iceland spar, is placed below the stage of the microscope, the field still appears light, although a part of its waves were cut off by the polarizer; but when the analyzer, which is another crystal of Iceland spar, is also placed over the eye-piece of the microscope in such a way that its position is at right angles to that of the polarizer, the light is wholly interrupted and the field is dark. In the case of *isometric* crystals the axes are all of equal length, and their planes all interfere with the ray of light equally. Hence its waves are not separated nor differently retarded, and they emerge from such crystals without polarization. Amorphous and isometric substances are thus simply refractive, or " single-refracting," and are called isotropic.

In the case of *tetragonal* crystals the axes are not all of the same length, and the waves of light on entering such a crystal are propagated with greatest ease in the direction of its longest axis. The vertical axis, which is perpendicular to the lateral axes, may be the longest, or it may be the shortest. The two lateral axes are equal, and they do not differ in the ease with which they transmit the waves of light. Hence a beam of light, on emerging

***System of Mineralogy*. 1868. *Text-Book of Minerology*. 1877.

from a tetragonal crystal, or a thin section of the same,* is separated into two sets of waves, or in other words, each wave is divided into two parts, one in advance of the other, and each set has the properties of polarized light. These sets advance parallel to each other, but the vibrations of the waves of the two sets are at right angels to one another. In the Nicol prisms one of these sets, known as the "ordinary ray," is so far diverted from its course before it leaves the prism that by an artificial combination of the parts of the prism it is wholly reflected and destroyed against the blackened sides of the prism. This leaves only one set of vibrations to pass through the prism, and they emerge a completely polarized ray. If a beam of light from the lower Nicol passes through a thin section of a tetragonal crystal in a direction parallel to the vertical axis, it is affected by the crystal equally in all directions, because the lateral axes, being equal and arranged symetrically about the vertical axis, allow the waves to pass in the same manner as an isotropic substance. If such a section be placed on the stage of the microscope and at the same time the upper and lower Nicol prisms are placed so that their planes of polarization are crossed, the light from the lower Nicol passes unmodified through the section, but is intercepted by the upper Nicol, and the field of the microscope is dark. If the Nicols are made parallel, the ray passes through, and the field is light. On the other hand, if a beam of light from the lower Nicol is allowed to fall upon a thin section of a tetragonal crystal in a direction perpendicular to the vertical axis, it meets with different resistance in different directions, at right angles to each other, and is at once divided into two sets of vibrations. One set is parallel to the vertical axis, and the other is perpendicular to it. If, however, the direction of the vibration of the waves from the lower Nicol exactly coincides with the direction of the vertical axis in the thin section, the waves are not thus divided, but pass through the section unmodified. This is also the case if it coincides with the direction of the lateral axis, or is perpendicular to the vertical axis. Hence, if the Nicols are crossed, such a section, on being rotated between them on the stage, will be *colored*, by the interference of its transmitted light, in all positions except when the axes coincide with the directions of the Nicols, in which cases the light from the lower Nicol, being allowed to pass unmodified, is intercepted by the upper Nicol, and the field is dark. This occurs four times in making a complete revolution of the stage. If the Nicols are

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* Except it be cut perpendicular to the vertical axis.

parallel, there will be four positions, removed 90° from each other, in which the section will be light, instead of dark, and in all other positions it will be colored.

In the case of *hexagonal* crystals, as their axes are situated with respect to each other exactly like those of tetragonal, *i. e.*, each perpendicular to the other two, and the vertical longer or shorter than the lateral, which are equal to each other, their optical characters are the same as those of tetragonal. They can be distinguished by the forms of their sections, cut perpendicular to the vertical axis. Tetragonal crystals thus cut have four or eight sides, but hexagonal have six, or some other multiple of three. Hexagonal and tetragonal crystals are called uniaxial, because there is but one axis in the direction of which they act as isotropic substances. It is that of the crystallographic vertical axis.

When tetragonal or hexagonal crystals are examined in convergent polarized light, a basal section shows, at crossed Nicols, a series of rings of color and a dark cross. This convergent light is usually obtained by special apparatus; but Mr. Geo. W. Hawes describes a method of examining crystals which have some considerable size, in convergent light in the common microscope,* when the analyzer is placed above the ocular. By removing the ocular and replacing the analyzer, the field of view is made small, and the magnifying power of the instrument is destroyed; but the peculiar ring system and the cross bars are distinctly visible in many basal sections of such crystals.

Mineral crystals belonging to the *Orthorhombic* system have three axes at right angles to each other, but they are all of different lengths. Light, in passing through such a crystal finds three directions, one of greatest ease, one of least, and one which is the mean of these. Hence, when a ray enters a thin section cut in any direction, it is doubly refracted and separated into two sets of waves having their vibrations at right angles to each other. One set vibrates in the direction of the greatest ease of movement, and the other in the direction of the least, and these correspond with two of the crystallographic axes. When a thin section of one of these crystals is brought between the Nicols, when they are crossed, it is colored in all positions, except when the direction of a crystallographic axis coincides with the plane of vibration of the light, when it will be dark. This occurs at four different places in the rotation of the stage, and they are separated from each other ninety degrees. Orthorhombic

*Mineralogy and Lithology of New Hampshire. Geol. Survey, Part IV. 1878.

crystals, moreover, are isotropic, *i. e.*, remain dark between crossed Nicols during an entire revolution of the stage, in two directions, and for this reason they are called biaxial. These directions, or optical axes, are in the plane of the greatest and least ease of movement of light, and make equal angles on opposite sides of the axes of least elasticity. If a section cut perpendicular to one of these optical axes be examined in convergent light, in the same manner as already mentioned with uniaxial minerals, the field will be colored by a series of rings, and a single dark bar will be seen crossing the field, which will revolve on the rotating stage in the direction opposite to that in which the stage is revolved.

Minerals belonging to the *monoclinic* system have three axes for the movement of light, as in orthorhombic crystals; but these do not correspond with the crystallographic axes. One of them corresponds with the orthodiagonal axis, and the others are at right angles to this axis and to each other, and lie in the plane that includes both the vertical and the clinodiagonal axes, and parallel to the clinopinacoid faces. Hence, in many respects the optical characters of monoclinic crystals are like those of orthorhombic. If the two rectangular axes of light-movement in any thin section coincide with the axes of the two Nicols, crossed, the field of the microscope remains dark, but in all other positions it is colored. Sections parallel to the base, or to orthopinacoid faces, answer these conditions. Sections parallel to the clinopinacoid face are employed to determine the angle between one of the axes of elasticity and the clinodiagonal axis. This is done by aligning the edges or the cleavages of the section with the spider lines in the ocular so that the vertical axis coincides in direction with the plane of vibration of light from the lower Nicol. In this position the field is colored, although the Nicols are crossed, showing that the vertical axis does not coincide with the axis of light-movement. By rotating the thin section on the stage, between crossed Nicols, the field soon becomes dark, which implies that an axis of light-movement coincides with the plane of polarized light from the lower Nicol. The angle through which the section was rotated is the angle between the vertical axis and the axis of light-movement. By rotating it still further, the field becomes colored and then dark again at 90° from the point at which it was last dark, which implies that another axis of light-movement, at right angles to the last, coincides in direction with the plane of vibration from the lower Nicol prism. If a thin section be made parallel to the base, or the orthopinacoid, it will contain the orthodiagonal axis and the vertical axis, which are at right angles to each other. A

the orthodiagonal is also an axis of light-movement, the plane of vibration from the lower Nicol will coincide with it, and the effect will be the same as in a similar section of an orthorhombic crystal, viz.: the field will remain dark at crossed Nicols when these axes are brought into coincidence. In monoclinic crystals, moreover, there are two optic axes, that is, directions in which, if a thin section be cut, the effect in polarized light is the same as produced by an isotropic body, and these axes coincide with the directions of the greatest and least ease of light-movement. The interference figures produced by examining, in converging light, a thin section of a monoclinic crystal, cut perpendicular to these optic axes, are the same as seen in similar sections of orthorhombic crystals, and these axes can be determined by such examination of the different elasticity axes in succession in sections cut perpendicular to the same.

In *triclinic* crystals there is an entire want of conformity between the crystallographic axes and the directions of light-movement. While the former are all inclined to each other, the latter are all perpendicular to each other. Hence, when the vibration plane of the lower Nicol corresponds with the direction of any of the crystallographic axes, a thin section between crossed Nicols will never be dark, but must be rotated to become so, the amount of rotation being entirely arbitrary, but dependent on the species of the mineral and the direction of the section. They also have two optic axes, round which the arrangement of lines and planes in the crystal is such as to act symmetrically on a ray of light in all directions, and hence to produce the same effect as isotropic substances.

*Circular Polarization* is that effect on a ray of light which is produced by some uniaxial crystals when it passes through a section cut perpendicular to the vertical axis. The ray, instead of being polarized at right angles, is circularly polarized; that is, its waves of different lengths, as blue, or yellow, or red, are retarded unequally, and between crossed Nicols any one of these colors can be intercepted by rotating the analyzer a little, according to the thickness of the plate, so as to show a field wholly of one color. This is taken advantage of in the examination of monoclinic and triclinic crystals, in order to determine the angle between the axis of light-movement and the axis of the crystal more accurately than can be done by simply noting the point of greatest extinction of light, as already described under monoclinic crystals. If a quartz plate 3¾ mm. in thickness, cut perpendicular to the vertical axis, be placed between crossed Nicols directly over the objective

in the tube of the microscope, and the analyzer rotated so far as necessary to intercept the blue rays of the light, the whole field will be blue. If then a section of a monoclinic crystal, cut parallel to the clinopinacoid, be put upon the stage, the field of view will be changed in color according to the mineral, but by rotation it can be made to appear blue again, and this will take place when an axis of light-movement coincides with the vibration plane of the lower Nicol. If now it be carefully rotated again so as to bring its crystallographic axis parallel with one of the hair-lines in the ocular, the amount of rotation is the angle between the axis of light-movement and the crystallographic axis.

It will be seen that there are three kinds of axes in crystals, which are to be kept distinct.

1. The *crystallographic axes*, around which the crystals are built in planes and lines.

2. The *axes of elasticity*, or ease of light-movement, parallel with which are the planes of vibration of polarized light.

3. The *optic axes*, in the direction of which, if viewed in polarized light, between crossed Nicols, the section acts like an isotropic body.

Some minerals, such as magnetite and pyrite, are wholly opaque, and however thin they may be ground, they are constantly dark. Such must be examined in reflected light, which may be intensified by a bull's-eye condenser, or by parabolic reflectors, of which there are various styles. Some minerals are characteristically colored, even in ordinary transmitted light. The chlorites are generally green, and the pyroxenes are brown or greenish-brown. Some polarize light characteristically, and at once produce such colors or such bands of color as to distinguish them. The triclinic feldspars are remarkable for the striation and banding of the colors of the thin section seen between crossed Nicols. Quartz is characteristically limpid and clear, with beautiful colors in polarized light. In some minerals the directions of the principal cleavages are characteristic. Pyroxene is distinguished from amphibole by the different angle of cleavage seen in a basal section, though in other respects they are very similar. Some minerals are *pleocroic, i. e.*, certain colored rays are absorbed, and, on emerging from the section, a beam of light presents different colored rays. Some are *dichroic*, transmitting two colors, and some *trichroic*. Some simply absorb more light of all kinds in some planes than in others, becoming slightly darker, and then light again on rotation with the analyzer romoved.

Thus, by the employment of the principles of polarized light,

combined with the magnifying quality of the microscope, the internal structure and minutest imperfections and impurities of minerals may be ascertained. A thin section of a crystalline rock presents several minerals at once, cut at various angles with the crystallographic and other axes, and exhibits a field for the use of the nicest discrimination and the most exact mechanical apparatus, but which, when fully wrought out, rewards the laborer with the most abundant and satisfactory fruits.

Those interested in this branch of Geology are referred to the following works:

*Rutley*—The Study of Rocks; 1879. London.

*Hawes*—The New Hampshire Geological Survey, Part IV; 1878.

*Rosenbusch*—Mikroskopische Physiographie der Petrographisch wichtigen Mineralien.

*Zirkel*—Mik. Beschaff. d. Min. und Gesteine.

" —Report of the 40th Parallel Survey; Vol. VI. Wash'n.

" —Lehrbuch der Petrographie; 1866. Bonn.

*Dana*, J. D.—System of Mineralogy; 1868. New Haven.

*Dana*, E. S.—Text-book of Mineralogy; 1877. New Haven.

*Decloizeaux*—Manuel de Mineralogie; 1862. Paris.

*La Saulx*—Von Elemente der Petrographie; 1875. Bonn.

*Spottiswoode*—Polarization of Light. "Nature Series;" 1874.

*Boricky*—Elemente einen neuen Chem-mikroskop, Mineral und Gesteins Analyse; 1877.

*Decloizeaux*—Memoire sur l'emploi du Microscope Polarisant.

*Queckett*—Treatise on the Microscope.

*Beale*—How to Work with the Microscope; 5th edition, 1880. Philadelphia.

Great diversity prevails in the nomenclature of the crystalline rocks. Not only do different authors, in some cases, employ different names for the same rock in Europe, but the same names are employed with different or with special or exceptional signification. This confusion, already to some extent apparent in American petrological literature, is likely to be perpetuated unless some criterion or some codified principles of nomenclature shall be generally adopted. Prof. J. D. Dana has recently made the attempt* to correct some of the errors that have grown up in the use of terms, and after discarding some of the distinctions that have been made between rocks that really are mineralogically and chemically identical, he presents a series of eight groups, which, not including calcareous and quartzose rocks, will cover, in a

*American Journal of Science and Arts. Third Series. Vol. XVI.

systematic and consistent scheme, the crystalline rocks of the earth. He says:—"Since leucite is a potash-alumina silicate, like orthoclose and microcline (it affording twenty per cent. or more of potash), it is here referred to the same group with the potash feldspars; and nephelite, sodalite and the saussurites being eminently soda-bearing species, they are included with the soda lime feldspars (anorthite to albite). This reference for lithological purposes of these minerals is sustained by their resemblance to the feldspars in constituents, and also in the quantivalent ratios between the alkalies, alumina, and silica, this ratio being in leucite 1:3:8, as in andesite, and in sodalite and nephelite 1:3:4 as in anorthite. The term *potash feldspar*, as used in the headings below is hence to be understood as covering orthoclase, microcline and leucite; and *soda lime feldspar* as including the triclinic feldspars from anorthite to albite, and also nephelite, sodalite, and the saussurites.

"The arrangement is as follows: In the first series the rocks graduate into kinds which are all feldspar, and into others that are all mica; and yet the amount of potash present is approximately the same.

I. The Mica and Potash-Feldspar Series: including Granite, Granulyte, Gneiss, Protogine, Mica Schist, etc., Felsyte, Trachyte, etc., and the Leucite rock of Wyoming.

II. The Mica and Soda-Lime Feldspar Series: including Kersantite, Kinzigite, and the nephelitic kinds—Miascyte, Ditroyte, Phonolyte, etc. (These nephelitic kinds belong almost as well in the preceding series.)

III. The Hornblende and Potash-Feldspar Series: including Syenyte, (with quartz syenyte) Syenyte Gneiss, Hornblende schist, Amphibolyte, Anakyte (this last containing epidote in place of Hornblende); and the nephelitic species Zircon-Syenyte, Foyayte.

IV. The Hornblende and Soda-Lime-Feldspar Series: including Dioryte (with Propylyte) Andesyte, Labradoryte (or Labrador dioryte) etc., and the saussurite rock Euphotide.

V. The Pyroxene and Potash-Feldspar Series: including Amphigenyte.

VI. The Pyroxene and Soda-Lime-Feldspar Series: including Augite-Andesyte, Noryte (Hypersthenyte and Gabbro in

part), Hypersthenyte, (containing true Hypersthene), Dolerye, (comprising Basalt and Diabase), Nephelinyte, etc.

VII. Pyroxene, Garnet, Epidote and Chrysolite rocks containing little or no Feldspar: including Pyroxenyte, Lherzolyte, Garnetyte (Garnet rock), Eclogyte, Epidosyte, Chrysolyte or Dunyte (Chrysolite rock), etc.

VIII. Hydrous Magnesian and Aluminous rocks, containing little or no Feldspar: including Chlorite schist, Talcose schist, Serpentine, Ophiolyte, Pyrophyllite schist, etc."

*The Cupriferous Series at Duluth.*

The rock at Duluth known as the "Rice Point Granite" affords a good illustration of the use of the polarizing microscope, and of the problems that surround the geologist in working out the stratigraphy and mineral composition of the rocks of the northern part of the State. While this rock is popularly styled *granite,* it cannot be so named by any recognized principles of lithology, except that its texture is generally like that which the word granite implies, viz., *granular.* Its chief ingredients, which are always present, are Plagioclase and Pyroxene, but the latter is sometimes very small in amount, and in some places is almost wanting. The rock has also titaniferous iron, generally magnetic, almost always present, and sometimes in quantity sufficient to render it an iron ore of low grade, while in many parts this iron is wholly wanting. Pyrite, calcite, epidote, and chlorite also exist in some parts in accessory quantities, particularly as geodes, nests, and vein-fillings, or as products of change. The rock is firm, of a gray color, and massive, forming low mountain ranges.

The *Plagioclase* is provisionally taken for Labradorite, a soda-lime feldspar. It is finely striated on the easiest cleavage surface (0), and shows under the microscope a banded structure in thin sections between crossed Nicols, due to the frequent twinning which the triclinic feldspars all exhibit. In some parts of this formation, near Duluth, the plagioclase appears more like Anorthite. It is then in long, narrow, tabular crystals, rather than in crowded grains, or massive, and these crystals cut the pyroxene, from having been first formed in passing from a molten to a solid state.

The pyroxene, cut at random in a thin section of the rock, occasionally shows a foliation parallel to the orthopinacoid,

which is characteristic of the variety of pyroxene styled Diallage. It is of a brownish-yellow color, or nearly colorless when not partially decayed, and non-dichroic; and between crossed Nicols it polarizes in brilliant colors. Much of it is fibrous from incipient change, the products being ferrite and viridite, when it not only plainly shows a fibrous structure in ordinary transmitted light, but also has a more confused or clouded polarization between crossed Nicols. Sometimes minute, perfect crystals are seen. They are short, stout, monoclinic prisms, but more frequently the pyroxene is in grains that show no crystal faces, but simply fill the interstices between the plagioclase crystals, or embrace them.

The iron that is common in this rock seems to be always titaniferous. Very rarely any crystalline forms can be discerned. It seems to have formed in crystalline condition later than the plagioclase and pyroxene. It attaches itself to the poles of the magnet, but yields in decomposition *in situ*, a white subtranslucent or opaque substance characteristic of menaccanite.*

As to the proper designation of this rock, authorities would differ. It is plainly an eruptive rock. The prevailing usage in naming a rock of Silurian age, containing labradorite and lamellar pyroxene, requires the term Gabbro. The term Diabase would be applied by Mr. Rosenbusch when the pyroxene is of the aluminous variety called augite, and that term has been applied by Mr. Pumpelly to the "greenstones" of the Cupriferous Series in Michigan and Wisconsin (*Proceedings of the American Academy of Arts and Sciences*, Vol. XIII), while the term Dolerytе, made by Mr. Dana to embrace both Diabase and Basalt, is that which would be demanded by principles published by him in the *American Journal of Science and Arts* for November and December, 1878.

The geological interest connected with this rock is in its intimate associations with a series of metamorphic rocks, which show all stages of metamorphism from perfectly crystalline sienitic granite to a slightly changed or hardly indurated red shale and sandstone. The details of this association can not here be given. It is sufficient to say that at Duluth the red rock may be seen in the quarries suddenly replacing the eruptive rock, and extending sometimes superficially over several square rods in the midst of the igneous rock. In other places it fills interstices and wedge-shaped openings, and at various places in the hills a mile or two

* See the Fifth Annual Report of the Survey, 1876, for an analysis of an impure iron ore from near Duluth.

north of Duluth it may be seen in place forming a large part of the hills. It generally runs under the eruptive rock, but sometimes seems to have been as perfectly fluid as the other, and rises massively to the general surface. The most highly changed and crystalline parts of this red rock are in the higher elevations, where also the coarsest crystals of the eruptive rock are found. Not only do the series of traceable, successive changes from crystallization to sedimentary, fragmental structure, show this red rock to be of different origin from the eruptive rock, but its mineral composition is also equally strong evidence. It consists, when perfectly crystalline, largely of quartz, which is penetrated by numerous acicular crystals of apatite, of red orthoclase feldspar and hornblende. The quartz is in subangular grains, and constitutes from one-fourth to one-half of the whole. The orthoclase is reddened by ferric oxide, and very often its crystalline structure is lost by decay. Both these minerals are pierced by apatite crystals. The hornblende is in brownish-yellow grains, instead of greenish-yellow, and seldom shows, so far as examined, a characteristic dichroicism, though between crossed Nicols it sometimes shows the colors yellow and green in different grains. This rock also generally contains some magnetite in scattering cubes, and sometimes other unimportant accessories.

In its various stages of change this rock, associated with the foregoing eruptive rock, seems to extend along the Lake Superior shore northeastward as far as to Grand Portage, where it leaves the coast of Minnesota and passes under the lake to Isle Royale, a lower formation, making the shore line east of Grand Portage.

Although the actual extension of these red shales and sandstone layers westward from Duluth to Fond du Lac cannot be seen, owing to the prevalence of the drift, it is the most obvious hypothesis to parallelize them with the tilted red shales and sandstones of that locality. There is a similarity of topography extending from one place to the other. The great basin of the lake actually does extend up the St. Louis Valley as far as Fond du Lac, and a little beyond. The strike and dip of the red shales and sandstones is perfectly in accord with the same at Duluth. They are highly tilted at Fond du Lac as if disturbed by the same upheaval. They lie on the Huronian Slates above Fond du Lac, and succeed to them, or to the Animikie Group of Dr. T. S. Hunt, where they leave the shore line near Grand Portage. The identity of these shales and sandstones as one great group can hardly be questioned. This was first recognized by Messrs. Foster and

Whitney in 1849-50*, who regarded them as of the Potsdam age. The separate portions of the formation, with intervening beds of igneous outflow, have unconformable stratification, a necessary result of the disturbance that prevailed in the Lake Superior district during the time of their deposit. What bearing this may have on the reported existence of two sandstone formations along the south shore of Lake Superior, one known as the Keweenian series, involved with the igneous rocks, and the other distinctively as the Potsdam of New York, it is not yet possible to know; but along the northwestern shore of Lake Superior there is certainly no good reason for rejecting the identification of Messrs. Foster and Whitney, supplemented as it was by the unquestioned authority of Prof. James Hall. The incongruous and ponderous "Quebec Group" of the Canadian geologists was extended by Sir. W. E. Logan from the Canadian Territory along the northwestern shore of Lake Superior to Duluth, covering these rocks†, but in the present unsettled condition of the limits and nature of the rocks of that group‡, it is premature to admit of such conjectural extension, even if it be admitted that that group did not, as enlarged, involve much of the earlier Potsdam of New York, and as still further extended by Mr. Selwyn, the upper portion also of the Huronian, making it truly a "remarkable assemblage" to be embraced under a single designation. At the same time it can scarcely be denied that this series, known (with the accompanying igenous rocks) as the "Upper Copper Bearing rocks of Lake Superior," is the equivalent of some part of the eastern Quebec, as urged by Mr. Selwyn, and that there are "no good grounds for assigning either an age or an origin to the cupriferous diorytes, dolerytes and amygdoloids of the eastern townships different from that of the almost identical rocks of Lake Superior."‖ Now the age of the Fond du Lac sandstones is by very general assent of geologists regarded Potsdam. Prof. Irving has lately assigned them to the Potsdam, and colored them continuously with the sandstones that form the southwest shore of Lake Superior in

**Report on the Geology of the Lake Superior Land District.*

†See the geological map of Canada, published by the Canadian Survey in 1866. Alexander Murray had in 1847 assigned the sandstones at the east end of Lake Superior to the Potsdam age.

A historical summary of the whole question is given in T. Sterry Hunt's Report (E) on the Trap dykes and Azoic rocks of southeastern Pennsylvania.

‡See *The Geological Survey of Canada, Report for* 1877-1878, and The Canadian Naturalist, Vol. IX., Nos. 1, 2 and 3.

‖ Compare the Fifth Annual Report on the Geological and Natural History Survey of Minnesota, p. 29; also American Journal of Science, 2nd Series, Vol. XXIII, p. 305, where Mr. Whitney has reviewed the subject.

Wisconsin. We hence see the Potsdam in its extension to Duluth involved with these igneous rocks, in upheaval and metamorphism,* and cannot resist the conviction that the whole series known as the Upper Copper Bearing Rocks, or as the Keweenian, or as the Quebec Group, on different authorities, was correctly assigned to the Potsdam at first by Messrs. Foster, Whitney and Hall in 1849, and subsequently by D. D. Owen.

It has been noticed both at Duluth and at other points along the northwest shore of Lake Superior that the Cupriferous rocks show more coarsely and sometimes a porphyritically crystalline structure at points a few miles away from the lake, and especially in the elevated portions, as in the range of hills at Poplar river, known as the Saw-Teeth Mountains. In descending from these hill-ranges the structure gradually becomes finer, and near the coast the rock is more evidently the result of sudden cooling of molten matter, the red shales and conglomerates being simply amygdaloidal, and the igneous rock preserving the wrinkled surfaces and vesicular structure of the successive outflows. At Duluth this succession of changes in the igneous rock is easily traceable, by reason of the removal of the forest and the frequent exposures of the rock throughout the city in the grading of the streets and other excavations. Coincident with this change is the change in the metamorphism of the sedimentary layers. Near the tops of the hills, and at points far inland, the sedimentary rocks are perfectly crystalline, but they almost always show a red color; toward the lake they are finer-grained, and are sometimes hard and "jaspery," with conchoidal fracture. On getting further still from the seat of the metamorphosing forces their real fragmental character is fully revealed. They pass through the stages of hardened siliceous slate and red porphyry to laumontitic calcareous amygdaloid and conglomerate, and even to a true shale, preserving the ripple-marks of gently agitated water. This changed condition of the Potsdam occupies a large area in northeastern Minnesota next south and east of the strike of the Huronian and Animikie belts, and its full extent has not yet been ascertained. What has here been said is intended only as an introduction to the full description of the facts, and the discussion of these interesting geological questions which can be solved so quickly, and are destined to be solved so largely by the use of the polarizing microscope.

*See R. D. Irving in Transactions of the Wisconsin Academy of Science, Arts, and Letters, 1873-4, p. 117.

# III.

# THE MUSEUM.

The two rooms in the main University building used for the General Museum, after a long period of confusion, during some of which one or both of them were closed to promiscuous visitation, were put into good order in April, on the completion of the mounting of the *Megatherium Cuvieri*, and were regularly opened to general admission. After the rearrangement of the larger of the Ward series of casts, on suitable supports about the room, the zoological apartment afforded a very inviting and instructive appearance, and the Musuem was much visited both by the people of the city, by students, and by strangers. In the fall of the year the same room received a couple of new cases for the storage of zoological alcoholic specimens. These are placed near the center of the room, but necessarily hide some of the other cases, and crowd the aisles surrounding them; but no better plan could be devised. The room is too small, and if the specimens gathered at the present time were to be all put on exhibition, some other room would have to be provided. Prof. Hall also filled the upright case on the north side of the room with the smaller of the stuffed mammals, and with the soil samples gathered in various parts of the State. These last are in glass jars. Prof. Hall also rearranged some of the corals and sponges in the same room, removing the samples of artificial products, as polished marble slate, etc., to the south room.

In the south room, where the minerals and geological specimens are kept, no additional cases have been built, but the minerals, which before were crowded have been rehandled, mostly by Prof. Hall, and so arranged that they follow successively, from case to case, the system of classification and the numeration of Prof. Dana.

The principal accession to the Museum during the year has been, perhaps, the Estherville aerolite. This important specimen was purchased by the Board of Regents, and was obtained largely through the instrumentality of Prof. E. J. Thompson, who at th

request of the curator, has gathered all the facts attending its fall, and has presented a preliminary report on it. The specimen itself, after being photographed, was, by order of the Executive Committee delivered to Prof. Peckham for analysis. In a subsequent report a full exposition will be given of its chemical, mineralogical and internal structure, accompanied by illustrations. A cast was taken in plaster of Paris. It was then cut for analytical examination. A piece weighing about nine pounds has been sent to Prof. J. Lawrence Smith, who in return has sent the museum twenty from other specimens of meteoric iron and stone, some of them being from Africa, and others from Australia, Greenland, Hungary, Mexico, France, and Poland, as well as from various parts of the United States. The specimens from Greenland are taken from the basalt, and resemble meteoric iron in composition. One specimen from Mexico weighs six and three-fourths pounds, and another contains rare mineral *Daubreelite*. This valuable addition to the Museum makes our collection of meteorites one of the best in the United States: It is contained in a special case in the south room of the Museum.

Prof. Thompson says:

May 10, 1879, was a bright, clear, cloudless day. At 5 o'clock in the afternoon, in full sunshine, this meteorite passed through the air, exploded, and fell in the town of Estherville, Emmet county, Iowa, about ten or twelve miles below the southern boundary of Jackson county, Minnesota, in latitude 43 degrees 30 minutes north, longitude 94 degrees 50 minutes west from Greenwich.

The path it followed marked a course from northwest to southeast, and was seen for a distance of several hundred miles.

Mr. W. L. Wilkins, of Austin, told me, as he was traveling in the northwest part of Mower county, May 10, about 5 o'clock P. M., he heard an unusual crackling and hissing noise about him, and, upon looking up, saw to the west of him the meteor passing. This was more than 100 miles from where it fell.

Mr. Prichard, who resides in the northwest part of Blue Earth county, saw it pass as it seemed far to the northwest of him, and describes it as a most startling and wonderful phenomenon—a huge ball of fire, followed closely by a cloud of fire. Reports from localities still further northwest, some from Dakota, confirm the opinion that its direction was as above stated. Its appearance in the heavens was that of a huge globe of fire, attended by a fiery cloud. The inhabitants residing within the area of a circle whose diameter is six miles, for a few minutes were greatly alarmed; not more at the simple flying ball of fire, which seemed so near to them, than at the terrific explosions immediately above them. Those who did not see it thought an earthquake had occurred, and were in great terror. All agree essentially in giving the facts connected with its explosion and force. The noise accompanying its flight is described as rumbling, cracking, crashing, similar to

that produced by a train of cars crossing a long bridge; then came a very loud report, immediately followed by two distinct reports in quick succession, though not so explosive or loud as the first. It struck the ground in separate masses, together with smaller fragments scattered over an area of three or four miles. There were two large pieces which fell about two miles apart, in a direct northwest line, both at an angle of nearly eighty degrees.

The impressions of those who saw the meteor in the air just at the time of explosion was, that still another large mass fell not far distant. This has been confirmed by the recent finding of a piece weighing 150 pounds, by a trapper named Robert Pietz.

The largest mass, weighing 470 pounds, now at Keokuk, Iowa, penetrated a hard blue clay soil, covered with water, to the depth of twelve feet. The mass weighing 170 pounds, now at the State University, fell on a dry, grassy knoll, and was buried to the depth of five and a half feet below the surface. A few rods from the largest mass was found a fragment weighing thirty pounds, and a school-boy picked up a specimen weighing three pounds a little distance away from the largest. These resembled the great body of the meteorite in all respects.

There was no appreciable difference in time between the explosion and the striking on the earth. The form of all the pieces is like that of rudely detached masses from a quarry, or ejected from the mouth of a volcano. The mass in the museum of the University has an irregular rhomboidal outline, about fifteen by eighteen inches, of an average thickness of six inches, and when first obtained was covered, as most meteorites, with a black shining coat or crust. The largest mass is not so regular in its formation. It is more ragged, and bristles with points of nickelliferous iron. Prof. Heinrich of the Iowa State University pronounced it the most valuable of the two large masses; but a full analyses will probably determine them to be one and the same, while the nickelliferous iron seemed more abundant in the largest, the crystalline formations are far more numerous in the smaller.

Several observers saw the large masses when they struck the ground, and state positively that sod and gravel and dirt scattered far and near, and for a moment the air was filled with flying stones and small masses of earth. The largest struck near a school-house, the smaller within twenty or thirty rods of a dwelling, much to the terror of the inmates. The language of the good old lady sitting by the window at the time, in a measure describes their fright: "My soul! I thought the end of the world had come, and I fell on my face and waited." The concussion produced by its passage through the air was so great that glass was broken in the windows, and in many instances where men were working in the field their horses were completely stunned with fright.

The following is an account given me by one of the nearest eye witnesses: "I was ploughing corn and my team was making to the westward, when suddenly I was startled by a distant whirring sound, which grew louder and nearer, broken and crackling, and as I looked up towards the northwest I saw a large ball of fire sweeping, as it were, down upon me. Instantly there came a loud report, at once followed by a second and third, not so loud as the first. In a few moments several persons were on the spot where they saw it fall, and began digging—for what they knew not—only, as they expressed it, 'that ball of fire they saw fall there.'"

The earth through which it passed presented a cracked, baked appearance, and the openings in the ground made by the meteorites indicated a twisting or revolving motion, as they seemed bored as with a large augur. With reference to its altitude when first seen, and at the moment of the explosion, and the immediate descent, our knowledge, at best must be quite imperfect. Calculating as well as I have been able, from data given me by an expert and skillful civil engineer, who was at the time at work on the Southern Minnesota railroad, and who carefully as possible noted its appearance and attitude, I should judge its height to have been, before the reports were heard, from thirty to forty miles. At the time of explosion it must have been very much less. From a partial and yet unfinished computation, it is thought its velocity to have been between two and four miles per second.

In the lower portion of the mineral cases have been stored temporarily a large number of rock samples and of fossils from abroad, and from the State of Minnesota. Arrangements have been made for completing the shelving intended for these cases, when they will be more convenient and will contain nearly double their present contents.

In the laboratory of the survey a great many boxes have been opened, their contents labeled, the large specimens often dressed down to suitable size, and distributed into classes, registered when their names have been known, and got ready for exhibition in the Museum. The crystalline rocks of the State have yet to receive full examination, and have not been registered. They are simply numbered with blue shellac and alcohol, with the field number of the survey.

The report of Prof. Hall shows what zoological and botanical specimens have been collected by him and Mr. Roberts for the Museum. These are mainly not yet on exhibition, owing to lack of time and proper facilities for their preparation, but they are being arranged as fast as possible.

The accompanying catalogue of registered specimens shows the geological and mineralogical accessions during the year. Exchange of specimens has been made with Prof. C. H. Hitchcock, of the Geological Survey of New Hampshire, Mr. B. H. Wright of Penn Yan, New York, S. H. Baker of the Owatonna Academy, Prof. T. Egleston of the Columbia College School of Mines, and with the Museum of Technology. A part of the Estherville aerolite has also been exchanged with Prof. J. Lawrence Smith for a number of meteoric stones from different parts of the world.

Ever since the beginning of the geological survey a class of specimens has been increasing for which no provision has been made. They consist of ancient stone hammers, arrow-heads, Indian pottery, and other relics of the Mound Builders and the

Indians. It is designed to prepare a suitable place of deposit for these specimens, so that they may be on exhibition, and so that they may serve as a nucleus for the gathering of a full series of these interesting relics. As the State is settled these specimens are discovered, and unless there is a recognized agency for their collection and preservation they are lost sight of, or slip away to other museums. The General Museum of the University, being established by State law, is the proper place of deposit and exhibition of such articles. It is believed that the people of the State who have them in their possession will often be glad to place them in the museum, either temporarily or permanently, when they are once satisfied that they are to be carefully preserved.

## *Catalogue of Specimens Registered in the General Museum in* 1879.—Continued.

| Serial Number. | Obtained. | | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| | When. | Whence. | | | | | |
| 2734 | Ap'l, 1879. | Geol. Survey....... | Rhodochrosite.................................. | 1 | L. Superior, Mich........ | Huronian.. | By Exchange with S. H. Baker. |
| 2735 | " | " ....... | Pyrolusite.................................. | 1 | McComber Mine, Mich .. | " | " " |
| 2737 | " | " ....... | Gypsum.................................. | 1 | Grand Rapids, Mich ?.... | Carb....... | " " |
| 2740 | 1872. | " ....... | Calcareous Tufa.................................. | 1 | Near Oseola, Wis........ | ............ | N. H. Winchell. |
| 2741 | Oct., 1879. | " ....... | Surface Soil .................................. | 1 | Minneapolis............... | ............ | C. W. Hall, (moist ground near Monitor Plow works. |
| 2742 | 1872. | " ....... | So-called Tripoli.................................. | 1 | ½ m. above Stillwater, Brown's Cr.............. | Drift....... | N. H. Winchell. |
| 2743 | Nov., 1878 | " ....... | Madison Sandstone.................................. | 1 | Madison, Wis............ | Low. Mag.. | C. W. Hall. |
| 2744 | " | " ....... | Catlinite.................................. | 1 | Rice L., Barron Co., Wis. | Potsdam... | By Exchange with Prof. Daniells. |
| 2745 | " | C. W. Hall......... | Levanto Marble.................................. | 1 | Italy...................... | ............ | Presented by S. Tingley, Providence, R. I. |
| 2746 | Aug. 2, '79 | Col. H. G. Hicks... | Bituminous Coal with silicified wood............. | 1 | Oglesby, Ill.... ......... | Carb....... | Pres. by E. W. Jordan, Sioux City. |
| 2747 | Sep., 1879 | S. F. Peckham..... | Lepidolite.................................. | 1 | Windsor, Maine ......... | ............ | By Exchange with Mrs. Fish. |
| 2748 | Oct., 1878. | Geol. Survey....... | Thomsonites in the matrix.................................. | Indf | Good Harbor Bay, L. Sup | ............ | C. W. Hall. |
| 2749 | " | " ....... | Thomsonites.................................. | " | " " | ............ | C. W. Hall. |
| 2750 | " | " ....... | Sandstone.................................. | " | " " | ............ | C. W. Hall. |
| 2751 | Oct., 1877. | " ....... | Brick Clay.................................. | " | St. P., bet. Sibley & Waconta sts. | Drift....... | N. H. Winchell, (3 feet above red stratified clay.) |
| 2752 | Oct., 1872. | " ....... | Umber Clay.................................. | 4 | Austin, Minn............. | Cret........ | N. H. Winchell. |
| 2753 | " | " ....... | Silecious Nodules.................................. | 6 | " " ........... | " ...... | " |
| 2754 | " | " ....... | Cretaceous Clay.................................. | 1 | " " ........... | " ...... | " |
| 2755 | " | " ....... | Colored Cretaceous Clay.................................. | 4 | " " ........... | " ...... | " |
| 2756 | " | " ....... | Shakopee Limestone.... ... ...................... | 2 | St. Charles............... | Shak ...... | " |
| 2757 | Sep., 1879 | L. M. Ford......... | Lignite.................................. | 1 | Bismark, Dak. Ter ...... | Cret........ | Presented by L. M. Ford. |
| 2758 | July, 1879 | Geol. Survey....... | Copper, (Crystals in a Group) ...................... | 1 | Phenix Mine, Mich...... | Cup........ | N. H. Winchell. |
| 2759 | " | " ....... | Fluorite, (in Amethystine cubes) and Galenite (in octahedra).................................. | 1 | Thunder Bay, Ont....... | ............ | " |
| 2760 | " | " ....... | Quartz, ) Amethyst).................................. | 1 | " " ...... | ............ | " light stain of manganese |

*Catalogue of Specimens Registered in the General Museum in* 1879—Continued.

| Serial Number. | Obtained. When. | Obtained. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 2761 | July, 1879. | Geol. Survey | Quartz, (Amethyst) | 1 | Thunder Bay, Ont. | | N. H. W. Amethystine. |
| 2762 | " | " | Quartz, (Amethyst) | 1 | " " | | " stained with iron and manganese. |
| 2763 | " | " | Quartz, (Amethyst) | 1 | " " | | N. H. W., deeply colored with manganese. |
| 2764 | " | " | Quartz, (Amethyst) | 1 | " " | | N. H. W., deeply colored with manganese and iron. |
| 2765 | 1879. | " | Thomsonites | 15 | Terrace Pt., L. Superior | | N. H. W., Beach-worn. |
| 2766 | 1876. | Geo. F. Kunz | Rock charged with Franklinite and Zincite | 2 | Franklin, N. J. | | |
| 2767 | 1879. | N. H. Wiuchell | White Gypsum | 1 | Sandusky, Ohio | | N. H. Winchell. |
| 2768 | " | N. H. Winchell | Salina Limestone (fetid) | 1 | Put-in-Bay, L. Erie, O | | N. H. Winchell. |
| 2769 | 1876. | Cent. Exhib. | Pig Iron | 1 | Alabama | | Selma, Rome & Dalton R. R. |
| 2770 | Dec. 31, '79 | Geol. Survey | Quartzyte (red) | 4 | Devil's Lake, Wis. | Potsdam? | N. H. Winchell. |
| 2771 | " | " | Quartzyte (pink) | 2 | " " | " | " |
| 2772 | " | " | Quartzyte (coarse) | 2 | " " | " | " |
| 2773 | " | " | Talcoseschist | 3 | " " | | " |
| 2774 | 1875. | " | Slag (very porous) | 1 | Wyandot, Mich. | | Wyandot Rolling Mills. |
| 2775 | " | " | Loam Soil | | Fountain, Fillmore Co. | Drift | N. H. Winchell. |
| 2776 | 1877. | " | Red Stratified Clay (Tripoli?) | 1 | St. Paul | " | N. H. W., between Wacouta and Sibley streets. |
| 2777 | 1875. | " | Sandy Drift Soil | 1 | Westcott, Dakota Co | " | N. H. Winchell. |
| 2778 | " | " | Surface Soil | 1 | Hader, Goodhue Co. | " | " 4 miles N. of Hader. |
| 2779 | 1876. | " | Loam Soil | 1 | Oronoco | " | " |
| 2780 | " | " | Soil thrown up by Gophers | 1 | Sec. 1, Chatfield | " | " |
| 2781 | 1875. | " | Soil | 1 | Cannon Falls | " | " |
| 2782 | 1879. | " | Loam (Stratified) | 1 | Sec. 34, T. 50, R. 13, L. Sup | " | N. H. W. This lies over No. 77. |
| 2783 | 1876. | " | Blue Hardpan | 1 | St. Bonifacius | " | " |
| 2784 | 1877. | " | Lacustrine Clay | 1 | Winnipeg, Manitoba | " | " |
| 2785 | 1876. | " | Soil | 1 | Thomson, Minn. | " | " |
| 2786 | 1876. | " | Yellow Hardpan | 1 | St. Bonifacius, Hen. Co. | " | " |

## *Catalogue of Specimens Registered in the General Museum in* 1879.—Continued.

| Serial Number. | OBTAINED. When. | OBTAINED. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 2787 | 1875. | Geol. Survey | Soil of Zumbro Valley | 1 | Zumbrota | Drift | N. H. Winchell |
| 2788 | " | " | Soil of Cannon River Valley | 1 | Cannon Falls | " | " |
| 2789 | " | " | Soil of Spring Valley | 1 | Spring Valley | " | " |
| 2790 | " | " | Loam Soil | 1 | Chatfield, Sec. 36 | " | " Fillmore county. |
| 2791 | 1876. | " | Gravelly (Hardpan) Clay Subsoil | 1 | Minnetrista, Hen. Co. | " | " |
| 2792 | 1878. | " | Duluth Soil | 1 | Duluth | " | " |
| 2793 | 1877. | " | Drift Fossils | .... | Minneapolis | " | " |
| 2794 | 1879. | " | Beach Sand | 1 | Beaver Bay | " | " |
| 2795 | " | " | Tripoli (so called) | 1 | Stillwater | " | Presented by Mrs. A. M. Rice. |
| 2796 | " | " | Sioux Quarzyte, (supposed) | 1 | Emmetsburg, Ia. | Potsdam | From bottom of a well. |
| 2797 | 1876. | " | Unios | 1 | Minnehaha Point | ............ | Found among boulders and pieces of limerock 60 ft. above river. |
| 2798 | 1879. | " | Fragment of Boulder | 1 | Traverse Co., Minn. | Drift | Warren Upham, decayed fragments of limerock. |
| 2799 | " | " | "Concretions and Pebbles" | 4 | Detroit | " | Warren Upham. |
| 2800 | " | " | Conglomerate | 7 | New Ulm, (opposite) | Potsdam | Warren Upham. |
| 2801 | Jan. 1879. | C. H. Hitchcock | Diabase No. 1. | 1 | East Hanover, N. H. | Intrusive | By Exch. with Geol. Sur. of N. H. |
| 2802 | " | " | Diabase No. 2. | 1 | Mt. Washington River | " | " " " |
| 2803 | " | " | Diabase, (loose.) No. 3. | 1 | Rye, N. H. | " | " " " |
| 2804 | " | " | Diabase No. 4. | 1 | Bartlett, N. H. | " | " " " |
| 2805 | " | " | Mica Diabase No. 5. | 1 | Flume, Lincoln, N. H. | " | " " " |
| 2806 | " | " | Mica Diabase No. 6. | 1 | Wakefield, (not Dixville,) [N. H | " | " " " |
| 2807 | " | " | Mica Diabase No. 7. | 1 | Waterville, N. H | " | " " " |
| 2808 | " | " | Labradorite Porphyry No. 8. | 1 | Ossipee, N. H. | " | " " " |
| 2809 | " | " | Anorthite Diabase No. 9. | 1 | East Hanover, N. H. | " | " " " |
| 2810 | " | " | Anorthite Diabase No. 10. | 1 | Concord Vt. | " | " " " |
| 2811 | " | " | Olivine Diabase No. 11. | 1 | Campton Falls, N. H. | " | " " " |
| 2812 | " | " | Dioryte, (porphyritic.) No. 12. | 1 | Campton Falls, N. H. | " | " " " |
| 2813 | " | " | Dioryte, (porphyritic.) No. 13. | 1 | North Lisbon, N. H. | " | " " " |
| 2814 | " | " | Dioryte, (porphyritic,) No. 14. | 1 | North Lisbon, N. H. | " | " " " |

*Catalogue of Specimens Registered in the General Museum in* 1879.—Continued.

| Serial Number. | Obtained. When. | Obtained. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 2815 | Jan., 1879. | C. H. Hitchcock... | Dioryte, (porphyritic.)......No. 15. | 1 | Profile House, Franconia, | Intrusive... | By Exch. with Geol. Sur. of N. H |
| 2816 | " | " | Dioryte, (porphyritic.)......No. 16. | 1 | Dixville Notch. [N. H. | " | " " " |
| 2817 | " | " | Dioryte, (Porphyritic calcareous.)......No. 17. | 1 | Dixville Notch ...... | " | " " " |
| 2818 | " | " | Mica Dioryte, (calcareous.)......No. 18. | 1 | Stewartstown, N. H ...... | " | " " " |
| 2819 | " | " | Gabbro......No. 19. | 1 | Waterville, N. H...... | " | " " " |
| 2820 | " | " | Gabbro......No. 20. | 1 | Mt. Washington, N. H.. | " | " " " |
| 2821 | " | " | Gabbro......No. 21. | 1 | Gilford, N. H...... | Boulders... | " " " |
| 2822 | " | " | Gabbro, (decomposed.)......No. 22. | 1 | Waterville, N. H...... | Int. Bould's | " " " |
| 2823 | " | " | Labradorite, (loose.)......No. 23. | 1 | Stark, N. H...... | Norian?... | " " " |
| 2824 | " | " | Felsyte......No. 24. | 1 | Mt. Washington, R. N. H | Intrusive... | " " " |
| 2825 | " | " | Felsyte......No. 25. | 1 | Bemis Brook, N. H ...... | " | " " " |
| 2826 | " | " | Black Quartz, (porphyry)......No. 26. | 1 | North East Waterville... | Acidic Unstrat'd Metam. | " " " |
| 2827 | " | " | " " " ......No. 27. | 1 | Albany, N. H...... | " | " " " |
| 2828 | " | " | " " " ......No. 28. | 1 | Mt. Lafayette, N. H ...... | " | " " " |
| 2829 | " | " | Gray Quartz, (little Quartz.)......No. 29. | 1 | Groveton, N. H...... | " | " " " |
| 2830 | " | " | Red Quartz, (porphyry.) ......No. 30. | 1 | Pemiquasset, N. H ...... | " | " " " |
| 2831 | " | " | " " " ......No. 31. | 1 | Albany, N. H...... | " | " " " |
| 2832 | " | " | " " " ......No. 32. | 1 | Waterville, N. H...... | " | " " " |
| 2833 | " | " | " " (Granitic.)......No. 33. | 1 | Waterville, N. H...... | " | " " " |
| 2834 | " | " | Quartz Porphyry, (white.)......No. 34. | 1 | Dorchester, N. H...... | Metamorp'c | " " " |
| 2835 | " | " | Quartz Porphyry ......No. 35. | 1 | Waterville, N. H ...... | " | " " " |
| 2836 | " | " | Porphyry Conglomerate ......No. 36. | 1 | Waterville, N. H...... | " | " " " |
| 2837 | " | " | " " ......No. 37. | 1 | Albany, N. H...... | " | " " " |
| 2838 | " | " | Quartz Porphyry ......No. 38. | 1 | Twin Mountains, N. H .. | " | " " " |
| 2839 | " | " | " " (clay stone porphyry.)......No. 39. | 1 | Mt. Willard, S. Side, N. H | Albany Granite | " " " |
| 2840 | " | " | Breccia of Argillitic Schist......No. 40 | 1 | Mt. Pequaket, N. H...... | Pequaket Breccia. | " " " |

## *Catalogue of Specimens Registered in the General Museum in* 1879.—Continued.

| Serial Number. | OBTAINED. When. | OBTAINED. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 2841 | Jan., 1879. | C. H. Hitchcock... | Breccia of Argillitic Schist & Q'tz Porphyry. [No. 41 | 1 | Mt. Pequaket, N. H...... | Pequaket Breccia. | By Exch. with Geol. Sur. of N. H |
| 2842 | " | " | Quartz Porphyry, (including clay slate.....No. 42. | 1 | Mt. Willard, N. H ...... | " | " " " |
| 2843 | " | " | " " (Granitic.)................No. 43. | 1 | Mt. Pequaket, N. H...... | " | " " " |
| 2844 | " | " | " " ...........................No. 44. | 1 | Mt. Pequaket, N. H...... | " | " " " |
| 2845 | " | " | Muscovite Granite, (Gametiferous.).........No. 45. | 1 | Barrington, N. H........ | Rocki'gh'm | " " " |
| 2846 | " | " | " biotite granite. ...............No. 46. | 1 | Concord, N. H... ....... | Montalban. | " " " |
| 2847 | " | " | " " " ........ .......No. 47. | 1 | Fitzwilliam, N. H....... | " | " " " |
| 2848 | " | " | " " " ................No. 48. | 1 | Marlboro, N. H.......... | " | " " " |
| 2849 | " | " | " " " ................No. 49. | 1 | Troy, N. H.............. | " | " " " |
| 2850 | " | " | " " " ................No. 50. | 1 | Manchester, N. H........ | L. Winnepesogee Gneiss. | " " " |
| 2851 | " | " | " " " (little muscovite, dark.) [No. 51. | 1 | Plymouth, N. H ......... | Montalban. | " " " |
| 2852 | " | " | Muscovite biotite granite. ...............No. 52. | 1 | Hookset, N. H........... | L. Winnepesogee Gneiss. | " " " |
| 2853 | " | " | " " " ................No. 53. | 1 | Lunapee, N. H........... | " | " " " |
| 2854 | " | " | " " " ................No. 54. | 1 | Farmington, N. H....... | Montalban, | " " " |
| 2855 | " | " | " " " ................No. 55. | 1 | Essex Co., Vt........... | " | " " " |
| 2856 | " | " | " " " ................No. 56. | 1 | Effingham, N.H.......... | | " " " |
| 2857 | " | " | " " " ................No. 57. | 1 | Haverhill, N. H......... | Intrusive .. | " " " |
| 2858 | " | " | " " " ................No. 58. | 1 | Elephant's Head, N. H... | Montalban. | " " " |
| 2859 | " | " | " " " (coarser.).......No. 59. | 1 | Concord, N. H........... | " | " " " |
| 2860 | " | " | " " " (coarser.).......No. 60. | 1 | Fabyan's, N. H.......... | " | " " " |
| 2861 | " | " | " " " ................No. 61. | 1 | Dixville, N. H.......... | .......... | " " " |
| 2862 | " | " | " " disintegrating granite, [No. 62. | 1 | Conway, N. H ........... | Conway Granite. | " " " |
| 2863 | " | " | Biotite granite...........................No. 63. | 1 | Mt. Willard, N. H ....... | " | " " " |
| 2864 | " | " | " " (loose.)....................No. 64. | 1 | Crawford House, N. H.. | " | " " " |

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| Serial Number. | OBTAINED. When. | OBTAINED. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 2865 | Jan., 1879. | C. H. Hitchcock... | Biotite granite. (pink.)........No. 65. | 1 | Lincoln, N. H.....[N. H. | Conway Granite. | By Exch. with Geol. Sur. of N. H. |
| 2866 | " | " | " " (pink.)........No. 66. | 1 | Moose Mt. New Durham, | Conway Granite. | " " " |
| 2867 | " | " | " " (red.)........No. 67. | 1 | Stratford, N. H........ | | " " " |
| 2868 | " | " | " " ........No. 68. | 1 | Stark, N. H.......[sarge. | ........... | " " " |
| 2869 | " | " | " " pseudo-porphyritic........No. 69. | 1 | White House, Mt. Kear | ........... | " (not sent by C. H. H.) |
| 2870 | " | " | " " ........No. 70. | 1 | Mission Ridge, Mt. Kear- | ........... | " " " |
| 2871 | " | " | " " contains hornblende. ....No. 71. | 1 | Newmarket, N. H. [sarge | Exeter Granite. | " " " |
| 2872 | " | " | " " ........No. 72. | 1 | White Mt. Notch, N. H.. | Franco'ia Breccia. | " " " |
| 2873 | " | " | " " ........No. 73. | 1 | White Mt. Notch, N. H.. | " | " " " |
| 2874 | " | " | Gneiss, (included in No. 73.)........No. 74. | 1 | White Mt Notch, N. H.. | " | " " " |
| 2875 | " | " | Gneiss, (included in granite.)........No. 75. | .... | Franconia, N. H........ | " | " " " |
| 2876 | " | " | Mica, hornblende granite, (olive green.)....No. 76. | .... | Stratford, N. H........ | Chocorua Granite. | " " " |
| 2877 | " | " | " " " " No. 77. | .... | Bartlett, N. H........ | " | " " " |
| 2878 | " | " | " " " ........No. 78. | .... | Frankenstein Cliff, N. H. | " | " " " |
| 2879 | " | " | " " " (Albany granite) No. 79. | .... | Jackson, N. H........ | Albany Granite. | " " " |
| 2880 | " | " | " " " ........No. 80. | .... | Ossipee, N. H........ | Chocorua Granite. | " " " |
| 2881 | " | " | " " " ........No. 81. | .... | Waterville, N. H...[N. H | Conway Granite. | " " " |
| 2882 | " | " | " " " (red.)........No. 82. | .... | Goodrich Falls, Bartlett, | " | " " " |
| 2883 | " | " | Granite with muscovite and hornblende.....No. 83. | .... | Bemis Sawmill, N. H.... | ........... | " " " |
| 2884 | " | " | Hornblende Granite, (Albany Granite.).....No. 84. | .... | New Zealand Brook, N. H | ........... | " " " |
| 2885 | " | " | " " ........No. 85. | .... | Stark, N. H........ | ..... | " " " |
| 2886 | " | " | " " (red.)........No. 86. | .... | Bartlett, N. H........ | Conway Granite. | " " " |

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| Serial Number. | OBTAINED. When. | OBTAINED. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 2887 | Jan, 1879. | C. H. Hitchcock... | Hornblende Granite, (Albany Granite.).....No. 87. | 1 | Albany, N. H............ | Albany Granite. | By Exch. with Geol. Sur. of N. H. |
| 2888 | " | " | " " " ...No. 88. | 1 | Bemis, N. H ......... ... | " | " " " |
| 2889 | " | " | " " microscopic segmatyte. No. 89. | 1 | Mt. Carrigain, N. H...... | ............ | " " " |
| 2890 | " | " | " " ........................No. 90. | 1 | Stark, N. H.............. | Chocorua Granite. | " " " |
| 2891 | " | " | " " (red.)..................No. 91. | 1 | Waterville, N. H......... | ............ | " " " |
| 2892 | " | " | Granitell. ........ ........................No. 92. | 1 | Mt. Ascutney, Vt........ | ............ | " " " |
| 2893 | " | " | Feldspar from bed. .......................No. 93. | 1 | Newcastle, N. H......... | ............ | " " " |
| 2894 | " | " | Augite sienyte, (uralitic.) ..................No. 94. | 1 | Jackson, N. H..... | ............ | " " " |
| 2895 | " | " | Hornblende sienyte. .......................No. 95. | 1 | Red Hill, Moultonboro'gh [N. H. | ............ | " " " |
| 2896 | " | " | " " ........... ..........No. 96. | 1 | Columbia, N. H.......... | ............ | " " " |
| 2897 | " | " | " " ........ ...........No. 97. | 1 | Stark, N. H............... | ............ | " " " |
| 2898 | " | " | " " (very fine grained.)..No. 98. | 1 | Albany, N.H.. | | " " " |
| 2899 | " | " | Muscovite Gneiss, (garnetiferous.)..........No. 99. | 1 | Hinsdale (not Chester-[field) N. H | Cambrian Slate. | " " " |
| 2900 | " | " | " " .......................No. 100. | 1 | Nashua, N. H............ | ............ | " " " |
| 2901 | " | " | Biotite Gneiss..............................No. 101. | 1 | Holderness, N. H ........ | L. Winnipissiogee Gneiss. | " " " |
| 2902 | " | " | " " (quarried.) ...............No. 102. | 1 | Enfield, N. H............ | Bethle'm Gneiss. | " " " |
| 2903 | " | " | " " (little feldspar.)..........No. 103. | 1 | Whitefield, N. H......... | " | " " " |
| 2904 | " | " | " " (opalescent quartz.)......No. 104. | 1 | Bradford, Vt............. | Lisbon..... | " " " |
| 2905 | " | " | " " (pseudo porphyritic.).....No. 105. | 1 | Waterville, N. H......... | Porphy'c Gneiss. | " " " |
| 2906 | " | " | " " " " ....No. 106. | 1 | Franconia, N. H......... | " | " " " |
| 2907 | " | " | Biotite Muscovite Gneiss. (pseudo porphyritic.) [No. 107. | 1 | Newbury, N. H......... | " | " " " |

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|---|---|---|---|---|---|---|---|
| | When. | Whence. | | | | | |
| 2908 | Jan., 1879. | C. H. Hitchcock... | Biotite Muscovite Gneiss, (pseudo porphyritic.) [No. 108. | 1 | Meredith Village, N. H.. | Porphy'c Gneiss, | By Exch. with Geol. Sur. of N. H. |
| 2909 | " | " | Biotite Muscovite Gneiss, (pseudo porphyritic.) [No. 109. | 1 | Bethlehem, N. H ........ | " | " " " |
| 2910 | " | " | Biotite Muscovite Gness, (almost micaschist.) [No. 110. | 1 | Newport, N. H........ .. | | " " " |
| 2911 | " | " | Biotite Muscovite Gneiss, (little mica.) [No. 111. | 1 | Bethlehem, N. H......... | Bethle'm Gneiss. | " " " |
| 2912 | " | " | " " " ................No. 112. | 1 | Hanover, N. H........... | " | " " " |
| 2913 | " | " | " " " ................No. 113. | 1 | Whitefield, N. H......... | " | " " " |
| 2914 | " | " | " " " [No. 114.].............. | 1 | East pond, Wakefield, N. H | Montalban. | " " " |
| 2915 | " | " | Biotite Muscovite Gneiss (ganetiferous.)...No. 115. | 1 | Marlow, N. H........... | ............ | " " " |
| 2916 | " | " | " " " (granitic gneiss). No. 116. | 1 | N. W. from Crawford House, N. H........... | Montalban. | " " " |
| 2917 | " | " | " " " .................No. 117. | 1 | Ossipee, N. H............ | L. Winnipisseogee Gneiss. | " " " |
| 2918 | " | " | " " " .................No. 118. | 1 | Wakefield Corner, N. H. | " | " " " |
| 2919 | " | " | " " " .................No. 119. | 1 | Carroll, N. H............ | Bethle'm Gneiss. | " " " |
| 2920 | " | " | " " " (almost mica schist.) [No. 120. | 1 | Wentworth, N. H........ | L. Winnipisseogee Gneiss. | " " " |
| 2921 | " | " | Biotite Muscovite Gneiss. ...............No. 121. | 1 | Randolph, N. H ......... | " | " " " |
| 2922 | " | " | " " " ................ No. 122. | 1 | Salem, N. H............. | " | " " |
| 2923 | " | " | " Gneiss, (decayed mica pyrrhotite.). No. 123. | 1 | White Mt. Notch, N. H... | Montalban. | " " |
| 2924 | " | " | " Oligoclase gneiss, "W. granite." .No. 124. | 1 | Swanzey, N. H .......... | Bethle'm Gneiss. | " " |

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|---|---|---|---|---|---|---|---|
| 2925 | Jan., 1879, | C. H. Hitchcock … | Biotite Hornblende Gneiss. ……………No. 125. | 1 | Mt. Franklin, Swanzey, [N H. | L. Winnipisseogee Gneiss. | By Exch. with Geol. Sur. of N.H |
| 2926 | " | " | " " " ……………No. 126. | 1 | Littleton, N. H………… | Bethle'm Gneiss. | " " " |
| 2927 | " | " | " " " ……………No. 127. | 1 | Wolfeborough, N. H…… | L. Winnipisseogee Gneiss. | " " " |
| 2928 | " | " | Protogene gneiss. [No. 128.]…………………… | 1 | Littleton, N. H ………… | Lisbon …. | " " " |
| 2929 | " | " | Protogene gneiss, (pseudo porphyritic. ..No. 129. | 1 | Lancaster, N. H ……… | ………… | " " " |
| 2930 | " | " | " " ……………………No. 130. | 1 | Groveton, N. H……… | Lisbon …. | " " " |
| 2931 | " | " | " " (epidotic.) No. 131. | 1 | Walling's Quarry, Lebanon, N. H………… | ………… | " " " |
| 2932 | " | " | " " ……………………No. 132. | 1 | Lyman, N. H………… | Lisbon …. | " " " |
| 2933 | " | " | " " (red.) ……………No. 133. | 1 | Surry Summit, N. H…… | Bethle'm Gneiss. | " " " |
| 2934 | " | " | Mica schist. ……………………………No. 134. | 1 | Mt. Peqauket, N. H…… | Kearsa'ge Andalusite | " " " |
| 2935 | " | " | " " ……………………………No. 135. | 1 | Troy, N. H ………… | Montalban. | " " " |
| 2936 | " | " | " " ……………………………No. 136. | i | Ackworth Center, N. H.. | Mica Schist & Stauroli'e Rocks. | " " " |
| 2937 | " | " | " " (Amoskeag quarry.) ……No. 137. | 1 | Manchester, (not Bedford [N. H. | L. Winnipisseogee Gneiss. | " " " |
| 2938 | " | " | " " ……………………………No. 138. | 1 | Bemis, N. H………… | Montalban. | " " " |
| 2939 | " | " | " " (garnetiferous.)…………No. 139. | 1 | Wakefield, N. H….. … | " | " " " |
| 2940 | | " | " " ……………………………No. 140. | 1 | Epping, N. H………… | Merrimack. | " " " |

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| Serial Number. | OBTAINED. When. | OBTAINED. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 2941 | Jan., 1879. | C. H, Hitchcock ... | Mica schist (ncarly massive.)............No. 141. | 1 | White Mt. Notch, N. H.. | Kearsa'ge Andalusite. | By Exch. with Geol. Sur. of N. H. |
| 2942 | " | " | " " ..............................No. 142. | 1 | Orford, N. H............. | Mica Schist & Stanroli'e Rocks. | " " " |
| 2943 | " | " | " " ..............................No. 143. | 1 | Starkweather Stat'n, N. H | Lyman .... | " " " |
| 2944 | " | " | " " ..............................No. 144. | 1 | Jackson Falls, N. H...... | " | " " " |
| 2945 | " | " | " " ..............................No. 145. | 1 | Top of Mt. Washington.. | Montalban. | " " " |
| 2946 | " | " | " " (massive.)..................No. 146. | 1 | Mt. Wash. carriage road. | Kearsa'ge Andalusite. | " " " |
| 2947 | " | " | " " ..............................No. 147. | 1 | Littleton, N. H .......... | Mica Schist & Stauroli'e Rocks. | " " " |
| 2948 | " | " | " " (whetstone schist.)..........No. 148. | 1 | Piermont, N. H.......... | " | " " " |
| 2949 | " | " | " " (ferruginous.)................No. 149. | 1 | Ashland, N. H........... | ........... | " " " |
| 2950 | " | " | " " ..............................No. 150. | 1 | Colebrook, N. H......... | Lisbon..... | " " " |
| 2951 | " | " | " " ..............................No. 151. | 1 | Groveton, N. H.......... | " | " " " |
| 2952 | " | " | " " (fine grained.)...............No. 152. | 1 | North Lisbon, N. H...... | Helderberg | " " " |
| 2953 | " | " | " " (argillitic.).........  .......No. 153. | 1 | Groveton, N. H .......... | Lisbon..... | " " " |
| 2954 | " | " | " " ..............................No. 154. | 1 | Lydenborough, N. H..... | Rock'gham | " " " |
| 2955 | " | " | " " (calcareous.) ................No. 155. | 1 | Colebrook, N. H......... | Calciferous | " " " |
| 2956 | " | " | Andalusite Mica Schist........... .......No. 156. | 1 | Mt. Willard, N. H........ | Kearsa'ge Andalusite. | " " " |
| 2957 | " | " | " " " .................No. 157. | 1 | Mt. Washington, N. H... | " | " " " |
| 2958 | " | " | Chiastolite " " ............No. 158. | 1 | Mt. Wash. carriage road | " | " " " |

## *Catalogue of Specimens Registered in the General Museum in* 1879—Continued.

| Serial Numbers. | Obtained. When. | Obtained. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 2925 | Jan., 1879, | C. H. Hitchcock ... | Biotite Hornblende Gneiss. ..............No. 125. | 1 | Mt. Franklin, Swanzey, [N H. | L. Winnipisseogee Gneiss. | By Exch. with Geol. Sur. of N.H |
| 2926 | " | " | " " " ..............No. 126. | 1 | Littleton, N. H........... | Bethle'm Gneiss. | " " " |
| 2927 | " | " | " " " ..............No. 127. | 1 | Wolfeborough, N. H..... | L. Winnipisseogee Gneiss. | " " " |
| 2928 | " | " | Protogene gneiss. [No. 128.]............ ......... | 1 | Littleton, N. H .......... | Lisbon .... | " " " |
| 2929 | " | " | Protogene gneiss, (pseudo porphyritic. ..No. 129. | 1 | Lancaster, N. H ......... | ............ | " " " |
| 2930 | " | " | " " ..........................No. 130. | 1 | Groveton, N. H.......... | Lisbon .... | " " " |
| 2931 | " | " | " " (epidotic.) No. 131. | 1 | Walling's Quarry, Lebanon, N. H........... | ............ | " " " |
| 2932 | " | " | " " .........................No. 132. | 1 | Lyman, N. H............ | Lisbon .... | " " " |
| 2933 | " | " | " " (red.) ................No. 133. | 1 | Surry Summit, N. H..... | Bethle'm Gneiss. | " " " |
| 2934 | " | " | Mica schist. .............................No. 134. | 1 | Mt. Peqauket, N. H...... | Kearsa'ge Andalusite | " " " |
| 2935 | " | " | " " ...........................No. 135. | 1 | Troy, N. H ............. | Montalban. | " " " |
| 2936 | " | " | " " ........ .....................No. 136. | i | Ackworth Center, N. H.. | Mica Schist & Stauroli'e Rocks. | " " " |
| 2937 | " | " | " " (Amoskeag quarry.) ........No. 137. | 1 | Manchester, (not Bedford [N. H. | L. Winnipisseogee Gneiss. | " " " |
| 2938 | " | " | " " .............................No. 138. | 1 | Bemis, N. H............ | Montalban. | " " " |
| 2939 | " | " | " " (garnetiferous.)..............No. 139. | 1 | Wakefield, N. H..... ... | " | " " " |
| 2940 | | " | " " .............................No. 140. | 1 | Epping, N. H........... | Merrimack. | " " " |

## *Catalogue of Specimens Registered in the General Museum in* 1879—Continued.

| Serial Number. | OBTAINED. When. | OBTAINED. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 2941 | Jan., 1879. | C. H, Hitchcock ... | Mica schist (nearly massive.) ............ No. 141. | 1 | White Mt. Notch, N. H.. | Kearsa'ge Andalusite. | By Exch. with Geol. Sur. of N. H. |
| 2942 | " | " | " " ............................ No. 142. | 1 | Orford, N. H............ | Mica Schist & Stanroli'e Rocks. | " " " |
| 2943 | " | " | " " ............................ No. 143. | 1 | Starkweather Stat'n, N. H | Lyman .... | " " " |
| 2944 | " | " | " " ............................ No. 144. | 1 | Jackson Falls, N. H...... | " | " " " |
| 2945 | " | " | " " ............................ No. 145. | 1 | Top of Mt. Washington.. | Montalban. | " " " |
| 2946 | " | " | " " (massive.) .................. No. 146. | 1 | Mt. Wash. carriage road. | Kearsa'ge Andalusite. | " " " |
| 2947 | " | " | " " ............................ No. 147. | 1 | Littleton, N. H .......... | Mica Schist & Stauroli'e Rocks. | " " " |
| 2948 | " | " | " " (whetstone schist.) .......... No. 148. | 1 | Piermont, N. H.......... | " | " " " |
| 2949 | " | " | " " (ferruginous.) ................ No. 149. | 1 | Ashland, N. H........... | ............ | " " " |
| 2950 | " | " | " " ............................ No. 150. | 1 | Colebrook, N. H......... | Lisbon..... | " " " |
| 2951 | " | " | " " ............................ No. 151. | 1 | Groveton, N. H.......... | " | " " " |
| 2952 | " | " | " " (fine grained.) .............. No. 152. | 1 | North Lisbon, N. H...... | Helderberg | " " " |
| 2953 | " | " | " " (argillitic.) ................. No. 153. | 1 | Groveton, N. H .......... | Lisbon..... | " " " |
| 2954 | " | " | " " ............................ No. 154. | 1 | Lydenborough, N. H..... | Rock'gham | " " " |
| 2955 | " | " | " " (calcareous.) ................ No. 155. | 1 | Colebrook, N. H......... | Calciferous | " " " |
| 2956 | " | " | Andalusite Mica Schist.................. No. 156. | 1 | Mt. Willard, N. H........ | Kearsa'ge Andalusite. | " " " |
| 2957 | " | " | " " " ................. No. 157. | 1 | Mt. Washington, N. H... | " | " " " |
| 2958 | " | " | Chiastolite " " ............... No. 158. | 1 | Mt. Wash. carriage road | " | " " " |

## *Catalogue of Specimens Registered in the General Museum in* 1879—Continued.

| Serial Number. | Obtained. When. | Obtained. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 2959 | Jan., 1879. | C. H. Hitchcock... | Fibrolite Mica Schist. ....................No. 159. | 1 | Rumney, N. H.......... | Montalban. | By Exch. with Geol. Sur. of N. H. |
| 2960 | " | " | " " " ....................No. 160. | 1 | Top of Mt. Washington.. | " | " " " |
| 2961 | " | " | Staurolite " " ....................No. 161. | 1 | Enfield, N. H........... | Mica Schist & Stauroli'e Rocks. | " " " |
| 2962 | " | " | " " " ....................No. 162. | 1 | Charleston, N. H ........ | " | " " " |
| 2963 | " | " | Garnetiferous Mica Schist. ..............No. 163. | 1 | Top of Mt. Monadnock.. | Kearsa'ge Andalusite. | " " " |
| 2964 | " | " | Argillitic " " ..............No. 164. | 1 | Woodsville, N. H........ | Lyman .... | " " " |
| 2965 | " | " | " " " ..............No. 165. | 1 | Well's River, Vt......... | " | " " " |
| 2966 | " | " | " " " ..............No. 166. | 1 | Stark, N. H....... ...... | " | " " " |
| 2967 | " | " | " " " ..............No. 167. | 1 | Lisbon, N. H............ | Swift water formation. | " " " |
| 2968 | " | " | " " " with copper pyrites. [No. 168. | 1 | Lyman, N. H ........... | Lyman .... | " " " |
| 2969 | " | " | Argillitic Mica Schist, (black silicious.....No. 169. | 1 | Dalton, N. H ........... | Cambrian Slates. | " " " |
| 2970 | " | " | " " " ....................No. 170. | 1 | Dalton Copper Mine..... | " | " " " |
| 2971 | " | " | " " " ....................No. 171. | 1 | Piper Hill, Stewartstown | " | " " " |
| 2972 | " | " | " " " ....................No. 172. | 1 | Stewartstown, N. H..... | Mica Schist & Stauroli'e Rocks. | " " " |
| 2973 | " | " | " " " ....................No. 173. | 1 | Chesterfield, N. H........ | Cambrian Slates. | " " " |
| 2974 | " | " | " " " ....................No. 174. | 1 | Lyman, N. H ........... | Lyman .... | " " " |
| 2975 | " | " | " " " ....................No. 175. | 1 | Portsmouth, N. H........ | Merrimack. | " " " |

## *Catalogue of Specimens Registered in the General Museum in* 1879—Continued.

| Serial Number. | OBTAINED. When. | OBTAINED. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 2976 | Jan.,1879. | C. H. Hitchcock... | Argillitic Mica Schist, (with flattened pebbles.) [No. 176. | 1 | Hanover, N. H........... | Helderberg. | By Exch. with Geol. Sur. of N. H. |
| 2977 | " | " | Argillitic Mica Schist. (with staurolite and garnet crystals........................No. 177. | 1 | Bernardston, Mass....... | Mica Schist & Stauroli'e Rocks. | " " " |
| 2978 | " | " | Argillitic Mica Schist, (with staurolite and garnet crystals..............................No. 178. | 1 | Bernardston, Mass....... | " | " " " |
| 2979 | " | " | Argillitic Mica Schist, (garnetiferous,)....No. 179. | 1 | Hanover, N. H........... | ............ | " " " |
| 2980 | " | " | " " " " ....No. 180. | 1 | Lynn, N. H.............. | " | " " " |
| 2981 | " | " | " " " ....................No. 181. | 1 | East Lebanon, N. H...... | Cambrian Slates. | " " " |
| 2982 | " | " | " " " ....................No. 182. | 1 | Lyman, N. H............ | " | " " " |
| 2983 | " | " | " " " ....................No. 183. | 1 | Dixville Notch, N. H.... | Lyman .... | " " " |
| 2984 | " | " | Novaculite. (gray.) .......................No. 184. | 1 | Littleton, N. H.......... | Lisbon..... | " " " |
| 2985 | " | " | " (black.).........................No. 185. | 1 | Tamworth, N. H......... | ............ | " " " |
| 2986 | " | " | Quartz schist. ............................No. 186. | 1 | Hinsdale, N. H.......... | Coös....... | " " " |
| 2987 | " | " | " " ...........................No. 187. | 1 | Charleston, N. H........ | " | " " " |
| 2988 | " | " | " " ...........................No. 188. | 1 | Chesterfield, N. H. ..... | " | " " " |
| 2989 | " | " | " " (micaceous.)...............No. 189. | 1 | Littleton, N. H.......... | Mica Schist & Stauroli'e Rocks. | " " " |
| 2990 | " | " | " " ...........................No. 190. | 1 | Piermont, N. H.......... | Coös....... | " " " |
| 2991 | " | " | " " ...........................No. 191. | 1 | Orford, N. H............ | " | " " " |
| 2992 | " | " | " " ...........................No. 192. | 1 | Bernardston, Mass....... | " | " " " |
| 2993 | " | " | " " ...........................No. 193. | 1 | Winchester, N. H........ | " | " " " |
| 2994 | " | " | " " ...........................No. 194, | 1 | Hinsdale, N. H.......... | ............ | " " " |
| 2995 | " | " | " " (micaceous.)...............No. 195. | 1 | Lisbon, N. H............ | ............ | " " " |
| 2996 | " | " | " " ...........................No. 196. | 1 | Surry, N. H............. | ............ | " " " |

## *Catalogue of Specimens Registered in the General Museum in* 1879—Continued.

| Serial Number. | OBTAINED. | | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| | When. | Whence. | | | | | |
| 2997 | Jan., 1879. | C. H. Hitchcock... | Quartz schist................................No. 197. | 1 | Lancaster, N. H......... | Lyman .... | By Exch. with Geol. Sur. of N. H. |
| 2998 | " | " | " " (pyritiferous.)...............No. 198. | 1 | Dalton, N. H............. | " .... | " " " |
| 2999 | " | " | " " (pyritiferons.)...............No. 199. | 1 | Lyman, N. H.............. | " .... | " " " |
| 3000 | " | " | " " ...............................No. 200. | 1 | Hanover, N. H............. | Coös....... | " " " |
| 3001 | " | " | " " (Whetstone schist.)..........No. 201. | 1 | Connecticut Lake, N. H. | Lisbon..... | " " " |
| 3002 | " | " | " " (chloritic.)...................No. 202. | 1 | Lyman, N. H.............. | ............ | " " " |
| | " | " | " " ...............................No. 203. | 1 | Winchester, N. H........ | Coös....... | " " " |
| 3003 | " | " | Black quartz schist........................No. 204. | 1 | New Castle, N. H........ | Merrimac.. | " " " |
| 3004 | " | " | Quartz schist, (half fragmental.)...........No. 205. | 1 | Littleton, N. H......... | Helderberg. | " " " |
| 3005 | " | " | Quartzyte ...............................No. 206. | 1 | Surry, N. H.............. | L. Winnepiseogee, Gneiss. | " " " |
| 3006 | " | " | Quartzyte ...............................No. 207. | 1 | Raymond, N. H.......... | Rock'gham | " " " |
| 3007<br>3008 | " | " | Quartzyte. [No. 208] ............................ | 1 | Amherst, N. H.......... | L. Winnepiseogee, Gneiss. | " " " |
| 3009 | " | " | Quartzyte, (Buhr-stone.)...................No. 209. | 1 | Littleton, N. H.......... | Helderberg. | " " " |
| 3010 | " | " | Quartzyte, (Calcareous.)....................No. 210. | 1 | Jackson, N. H........... | Montalban. | " " " |
| 3011 | " | " | Metamorphic Dioryte......................No. 211. | 1 | Littleton, N. H.......... | Lisbon..... | " " " |
| 3012 | " | " | Metamorphic Dioryte......................No. 212. | 1 | Pittsburg, N. H.......... | " ..... | " " " |
| 3013 | " | " | Metamorphic Dioryte......................No. 213. | 1 | Cornish, N. H........... | " ..... | " " " |
| 3014 | " | " | Metamorphic quartz-dioryte...............No. 214. | 1 | Hanover, N. H.......... | " ..... | " " " |
| 3015 | " | " | Amphibolyte, containing triclinic feldspar. No. 215. | 1 | N. Lisbon N. H.......... | " ..... | " " " |
| 3016 | " | " | Amphibolyte ..............................No. 216. | 1 | Littleton, N. H ......... | " ..... | " " " |
| 3017 | " | " | Hornblende schist ........................No. 217. | 1 | Cornish, N. H............ | Huronian .. | " " " |
| 3018 | " | " | Hornblende schist .........................No. 218. | 1 | Winchester, N. H........ | Bethle'm, Gneiss. | " " " |
| 3019 | " | " | Hornblende schist, (black.)................No. 219. | 1 | Surry Summit, N. H..... | Huronian .. | " " |
| 3020 | | " | Hornblende schist, (black.)................No. 220. | 1 | Fitzwilliam, N. H ....... | Bethle'm, Gneiss. | " " |

## *Catalogue of Specimens Registered in the General Museum in* 1879—Continued.

| Serial Number. | Obtained. When. | Obtained. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 3021 | Jan., 1879. | C. H. Hitchcock... | Hornblende schist........................No. 221. | 1 | Piermont, N. H.......... | Huronian .. | By Exch. with Geol. Sur. of N. H. |
| 3022 | " | " | Hornblende schist........................No. 222. | 1 | Stark, N. H............. | " | " " " |
| 3023 | " | " | Hornblende schist........................No. 223. | 1 | Westmoreland, N. H..... | " | " " " |
| 3024 | " | " | Hornblende schist, (epidotic and chloritic.)No. 224. | 1 | Milan, N. H ............ | " | " " " |
| 3025 | " | " | Hornblende schist, (garnetiferous.)........No. 225. | 1 | Hanover, N. H........... | " | " " " |
| 3026 | " | " | Hornblende schist........................No. 226. | 1 | Hanover, N. H........... | " | " " " |
| 3027 | " | " | Chloritic quartz schist...................No. 227. | 1 | Lebanon, N. H........... | Mica schist and Staurolite Rocks | " " " |
| 3028 | " | " | Chlorite schist...........................No. 228. | 1 | Connecticut Lake, N. H.. | ............ | " " " |
| 3029 | " | " | Chlorite schist...........................No. 229. | 1 | Lisbon, N. H............ | ............ | " " " |
| 3030 | " | " | Chloritic Mica schist.....................No. 230. | 1 | Raymond, N. H .......... | ............ | " " " |
| 3031 | " | " | Chlorite schist...........................No. 231. | 1 | N. Lisbon, N. H......... | ............ | " " " |
| 3032 | " | " | Chlorite schist. .........................No. 232. | 1 | Dalton, N. H............ | Cambrian Slates. | " " " |
| 3033 | " | " | Clay slate, (Roofing slate.)...............No. 233. | 1 | Littleton, N. H......... | ............ | " " " |
| 3034 | " | " | Conglomerate.............................No. 234. | 1 | N. Lisbon, N. H......... | Cambrian Slates. | " " " |
| 3035 | " | " | Conglomerate.............................No. 235. | 1 | " ......... | " | " " " |
| 3036 | " | " | Auriferous Conglomerate..................No. 236. | 1 | Lyman, N. H............ | Aurif'ro's Conglom. | " " " |
| 3037 | " | " | Quartzyte, (vein stone) ..................No. 237. | 1 | Madison Lead Mine, N. H | Montalban. | " " " |
| 3038 | " | " | Quartzyte, (vein stone.)..................No. 238. | 1 | Cornish, N. H........... | Mica schist and Staurolite Rocks | " " " |
| 3039 | " | " | Quartzyte, (vein stone—auriferous.)........No. 239. | 1 | Dodge Mine, Lyman, N. H | Cambrian Slate. | " " " |

## *Catalogue of Specimens Registered in the General Museum in* 1879—Continued.

| Serial Number. | Obtained. When. | Obtained. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 3040 | Jan. 1879. | C. H. Hitchcock... | Soapstone.........No. 240 | 1 | Francistown, N. H....... | Ferruginous Slate | By Exch. with Geol. Sur. of N. H. |
| 3041 | " | " | Soapstone.........No. 241 | 1 | Lancaster, N. H......... | ............ | " " " |
| 3042 | " | " | Soapstone (talc schist).........No. 242 | 1 | Oxford, N. H............ | Lyman .... | " " " |
| 3043 | " | " | Soapstone (talc schist).........No. 243 | 1 | Oxford, N. H............ | Mica schist and Staurolite Rocks | " " " |
| 3044 | " | " | Limestone (micaceous).........No. 244 | 1 | Haverhill, N, H.......... | Bethle'm, Gneiss. | " " " |
| 3045 | " | " | Limestone (white).........No. 245 | 1 | N. Lisbon, N. H......... | Helderberg | " " " |
| 3046 | " | " | Limstone (gray).........No. 246 | 1 | Littleton, N. H.......... | " | " " " |
| 3047 | " | " | Limestone (crinoidal).........No. 247 | 1 | Bernardston, Mass....... | " | " " " |
| 3048 | " | " | Silicious limestone.........No. 248 | 1 | Cornish, N. H........... | Calciferous Mica schist. | " " " |
| 3049 | " | " | Dolomitic limestone (very silecious).........No. 249 | 1 | Lyman, N. H............ | Lyman,.... | " " " |
| 3050 | " | " | Magnetite.........No. 250 | 1 | Franconia, N. H......... | L, Winnipiseogee Gneiss. | " " " |
| 3051 | " | " | Tourmaline......... | 1 | Grafton, N. H........... | ............ | " " " |
| 3052 | " | " | Impure serpentine......... | 1 | Norwich, Vt............. | ............ | " " " |
| 3053 | " | " | Mica Schist (with dolomite crystals)......... | 1 | Hanover, N. H........... | ............ | " " " |
| 3054 | " | " | Massive triplite......... | 1 | Grafton, N. H........... | ............ | " " " |
| 3055 | " | " | Fibrolite schist (loose)......... | 1 | Littleton, N H........... | ............ | " " " |
| 3056 | " | " | Near decomposed gabbro......... | 1 | Waterville, N. H......... | ............ | " " " |
| 3057 | " | " | Porphyry dike in Lake Gneiss......... | 1 | Centre Harbor N. H...... | ............ | " " " |
| 3058 | June, 1879 | By purchase....... | Aerolite......... | 1 | Estherville, Iowa........ | ............ | Prof. E, J. Thompson. |
| 3059 | " | Geol. Survey....... | Brick, (maker, Wiest & Kruze)......... | 1 | Chaska.................. | ............ | Warren Upham. |
| 3060 | " | " | Brick, (maker, Meier)......... | 1 | Henderson............... | ............ | " |

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## *Catalogue of Specimens Registered in the General Museum in* 1879—Continued.

| Serial Number. | Obtained. When. | Obtained. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 3061 | June, 1879 | Geol. Survey | Brick, (maker, Gregg & Griswold) | 1 | Chaska | | Warren Upham. |
| 3062 | " | " | Brick, (maker, Winkelman) | 1 | New Ulm | | " |
| 3063 | " | " | Brick, (maker, Kranz) | 1 | Belle Plaine | | " |
| 3064 | " | " | Brick, (makers, Shalafle, Strobach and Streissguth) | 1 | Chaska | | " |
| 3065 | " | " | Brick, (maker, Ahtin) | 1 | Carver | | " |
| 3066 | " | " | Brick, (maker, Ahtin) | 1 | Carver | | " |
| 3067 | " | " | Brick, (maker, Wyman) | 1 | Hutchinson | | " |
| 3068 | " | " | Brick, (maker, Davidson) | 1 | St. Peter | | " |
| 3069 | " | " | Brick, (maker, Stoerket) | 1 | New Ulm | | " |
| 3070 | " | " | Brick, (maker, Warner) | 1 | Chaska | | " |
| 3071 | " | " | Brick, (maker, Matthei) | 1 | Henderson | | " |
| 3072 | " | " | Brick | 1 | Shingle Creek | | " |
| 3073 | " | " | Brick | 1 | Milwaukee, Wis. | | " |
| 3074 | " | " | Brick, (maker, Dauffenbach | 1 | New Ulm | | " |
| 3075 | June, 1879 | " | Fire-brick, (Maker, Felthausen) No. 1. | 1 | Milwaukee, Wis. | | |
| 3076 | Sept., 1876 | S. F. Peckham | Fibrous Quartz | 1 | Cranston, R. I. | Carbonif. | |
| 3077 | " | " | Bituminous Coal | 2 | Brewster Mine, Akron, O. | " | Showing mineral charcoal on [cleavage surface |
| 3078 | " | " | " " | 1 | " " " | " | Showing iridescence. |
| 3079 | " | " | Asphaltum, (Trinidad Pitch) | 1 | Pitch Lake, Trinidad, I. | Tertiary | |
| 3080 | " | " | Asphaltum, " " | 1 | " | " | Has been melted. |
| 3081 | " | " | Asphaltum | 1 | Ojai Ranche, Santa Bar- [bara, Cal | Miocene | |
| 3082 | " | " | Anthracite | 1 | Cranston, R. I. | Carbonif. | Metamorphosed nearly into [graphite. |
| 3083 | " | " | Coal Shale | 1 | Akron, O. | " | Showing alternations of fossils and shale. |
| 3084 | Oct. 2, '79 | " | Cryolite | 1 | Evigtok, W. Greenland | | Exchange with Mus. of Tech. |
| 3085 | " | " | Rhodonite, (Parisburgite) | 1 | Parisburg, Sweden | | " " |
| 3086 | " | " | Aragonite | 1 | Carlstad, Bohemia | | " deposit from hot springs |
| 3087 | " | " | Cassiterite | 1 | Zinnwald, Sax. | | By exchange, Mus. of Technology |
| 3088 | " | " | Apatite, (Ghosphorite) | 1 | Diez, Nassau | | " " Tech., used for manufacture of manure. |

## *Catalogue of Specimens Registered in the General Museum in* 1879.—Continued.

| Serial Number. | Obtained. When. | Obtained. Whence. | NAME. | No. of Specimens. | Locality | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 3089 | Oct. 2, '79 | S. F. Peckham.... | Crocoite.... | 1 | Beresowsk, Ural.... | .... | By exch. with Museum of Tech. |
| 3090 | " | " .... | Chrysoprase.... | 1 | Kosemütz, Silesia.... | .... | " " " |
| 3091 | " | " .... | Cryolite with Galenite, Siderite and Chalcopyrite | 1 | Evigtok, W. Greenland.. | .... | " " " |
| 3092 | " | " .... | Turquois.... | 1 | Fordansmühl. Silesia.... | .... | " " " |
| 3093 | " | " .... | Niccolite with Barite.... | 1 | Richelsdorf, Hessia.... | .... | " " " |
| 3094 | " | " .... | Alunite.... | 1 | Nagymazy, Hungary.... | .... | " " " |
| 3095 | " | " .... | Tarnovicite, Crystals with Galenite.... | 1 | Tarnowitz, Upper Silesia | .... | " " " |
| 3096 | " | " .... | Scheelite with Quartz.... | 1 | Zinnwald, Sax.... | .... | " " " |
| 3097 | " | " .... | Siderite in Cryolite.... | 1 | Evigtok, W. Greenland.. | .... | " " " |
| 3098 | " | " .... | "Soft Carbonate Ore".... | 2 | Leadville, Col.... | .... | By ex. with Mus. Tech., Iron Mine |
| 3099 | " | " .... | Nacrite.... | 1 | Lime Rock, R. I.... | .... | By ex. with Mus. of Technology. |
| 3100 | " | " .... | Manganite.... | 1 | Negaunee, Mich.... | .... | Geo. J. Brush, Mus. of Technology |
| 3101 | " | " .... | Native Copper in Calcite Crystals.... | 1 | Quincy Mine, Mich.... | .... | By ex. with Mus. of Technology. |
| 3102 | " | " .... | Pyropissite.... | 1 | Weissenfels. Sax. (near Kelle).... | .... | " " " |
| 3103 | " | " .... | Tellurium Pyrite (?).... | 1 | Sunshine, Col. Am. mine. | .... | " " " |
| 3104 | " | " .... | Siegburgite, (succinite, a fossil resin).... | 1 | Siegburg, Silesia.... | .... | " " " |
| 3105 | " | " .... | Mendipite.... | 1 | Burthen, Up. Silesia.... | .... | " " " |
| 3106 | " | " .... | Fulgerite.... | 1 | Starcynon, near Olkurz, Polonia.... | .... | " " " |
| 3107 | " | " .... | Amethyst.... | 1 | 19 ms. N. of Gd. Portage. | .... | " " " |
| 3108 | Oct. 3, '79 | R. O. Sweeny.... | Pyrite.... | 1 | Galena, Ill.... | .... | .... |
| 3109 | " | J. F. Tostevin.... | Tennessee Marble.... | 2 | Knoxville, Tenn.... | .... | .... |
| 3110 | " | " .... | " " (Crinoidal).... | 2 | Rogersville, Tenn.... | .... | .... |
| 3111 | " | " .... | Formoso Marble.... | 1 | Germany.... | .... | .... |
| 3112 | May 22, '75 | W. R. Marshall.... | Lignite.... | 1 | Missouri r. (near mouth of Knife R).... | .... | From 7 feet bed on E. side of R. |
| 3113 | Oct. 4, '79 | Geol. Survey.... | Sandstone, (in which are found the reptilian tracks [of the Conn. Valley | 2 | Middlefield, Conn.... | Triassic.... | C. W. Hall. |
| 3114 | " | " .... | Conglomerate.... | 2 | Meriden, Conn.... | " .... | " |
| 3115 | " | " .... | Sandstone, (coarse).... | 2 | " " | " .... | " |

## *Catalogue of Specimens Registered in the General Museum in* 1879—Continued.

| Serial Number. | OBTAINED. When. | OBTAINED. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 3116 | Oct. 4, '79 | Geol. Survey | Doleryte | 2 | Near Middlefield, Conn. | Triassic(?) | C. W. Hall. |
| 3117 | " | " | Sandstone | 2 | Long Meadow, Mass. | | " |
| 3118 | " | " | Conglomerate | 2 | Newton Highlands, Mass. | | " |
| 3119 | " | " | Gneiss, (Granitoid) | 2 | Gardner, Mass | | " |
| 3120 | " | " | Gneiss | .... | Royalston, Mass | | " |
| 3121 | " | " | Gneiss | .... | Orange, Mass | | " |
| 3122 | " | " | "Cape Ann Granite" | .... | Cape Ann, Mass | | " |
| 3123 | " | " | Granite, (finely Crystalline) | 2 | Fitzwilliam, N. H. | | " |
| 3124 | " | " | Granite | 3 | Fitchburg, Mass | | " |
| 3125 | " | " | Quartz Crystals | 3 | Greenwood, Maine | | " Presn'd by G.F. Leonard |
| 3126 | " | S. F. Peckham | Blende and Quartz | 3 | Eame's Mine, Pie I. L. Sup | | By ex. with Mus. of Technology. |
| 3127 | " | " | Blende, Galena and Quartz | 1 | " " | | " " " |
| 3128 | " | " | Magnetite | 1 | Port Henry, N. Y. | | " " " |
| 3129 | " | S. F. Peckham | Cannel Coal | 1 | Kanawha Co., W. Va. | Carb. | " " " |
| 3130 | " | " | Argentiferous Galena, (400 oz. of Sil. per ton) | 1 | Veto Lode, near Georgetown, Col. | | " " " |
| 3131 | " | " | Calcite | 4 | Pie Island, Lake Superior. | | " " " |
| 3132 | " | " | Black Band Ore, (Calcined) | 1 | Davis Creek, Kanawha Co., W. Va. | Carb | " " " |
| 3133 | " | " | Black Band Ore | 1 | Davis Creek, Kanawha Co., W. Va. | " | " " " |
| 3134 | " | " | Barite | 1 | Baker's Mine, Pigeon Pt. Lake Sup. | | " " " |
| 3135 | " | " | Barite and Calcite | 3 | Baker's Mine, Pigeon Pt., Lake Sup | | " " " |
| 3136 | " | " | Barite and Blende | 1 | Baker's Mine, Pigeon Pt., Lake Sup. | | " " " |
| 3137 | " | " | Drusy Quartz | 1 | Pigeon Pt. Lake Superior. | | " " " |
| 3138 | " | " | Graphite, (Pebbly) | 10 | " " | | " " " |
| 3139 | " | " | " (in matrix) | 1 | " " | | " " " |

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|---|---|---|---|---|---|---|---|
| 3140 | 1878. | C. L. Herrick | Buhrstone, (from the great mill explosion) | 4 | Minneapolis | | |
| 3141 | 1879. | Geol. Survey | Terra-Cotta Brick | 1 | Red Wing, Minn | | N. H. W. |
| 3142 | 1875. | " | Artificial Stone | 4 | Minneapolis | | N. H. W. |
| 3143 | 1873. | " | Unburnt Brick | 1 | Upper Agency, Minn. R. | | N. H. W., from the pile abandoned by the Indians on the outbreak, Aug. 19, 1862. |
| 3144 | 1878. | B. Juni | Buhrstone, (from the great mill explosion) | 1 | Minneapolis | | |
| 3145 | 1879. | G. F. Kunz | Lithio-Ferrite | 1 | Regensdorf, Westphalia | | |
| 3146 | " | Geol. Survey | Granite, (near the conglomerate) | 3 | Opposite New Ulm | | Warren Upham. |
| 3147 | " | " | Red Quartzyte | 2 | Faxon, (Doheny's Quar'y) | | " |
| 3148 | " | " | Siliceous Limestone | 2 | Jessenland, (Young's Qy.) | | " |
| 3149 | " | " | Red Quartzyte, (E. part of R. R. cut) | 3 | Near New Ulm, 30 rds. E. of the bridge | Potsdam | " |
| 3150 | " | " | " | 2 | Baasen's Qy, n. New Ulm | " | " |
| 3151 | " | Geo. F. Kunz | Chromite, ("Bird's Eye") | 1 | Maryland | | |
| 3152 | " | " | Tetrahedrite, ("Annivite") | 1 | Anniverthal, Switzerland | | |
| 3153 | " | " | Leucite | 1 | Vesuvius, Italy | | |
| 3154 | " | " | Hydrotalcite | 1 | St. Lawrence, N. Y. | | |
| 3155 | " | " | Pyroxene, (Malacolite) | 1 | Mähren | | |
| 3156 | " | " | Gadolinite | 1 | Ytterby, Sweden | | |
| 3157 | " | " | Arsenic, (native) | 1 | Freiburg, Saxony | | |
| 3158 | " | " | Arragonite, ("Mozzottite") | 1 | Chili, S. A. | | |
| 3159 | " | " | Euphyllite | 1 | Chester, Mass. | | |
| 3160 | " | " | Arragonite | 1 | Bilin, Bohemia | | |
| 3161 | " | " | Bismuth | 1 | England | | |
| 3162 | " | " | Wolchonskoit | 1 | Montague d'Effineatskaia Ural | | |
| 3163 | " | " | Berthierite | 1 | Braunsdorf, Saxony | | |
| 3164 | " | " | Shielite | 1 | Monroe, Conn. | | |
| 3165 | " | " | Chalcocite, (Redruthite) | 1 | England | | |

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|---|---|---|---|---|---|---|---|
| 3166 | 1879. | Geo. F. Kunz | Chabazite, (Phacolite) | 1 | Salest, Bohemia | | |
| 3167 | " | " | Menaccanite, (Washingtonite) | 1 | New York City | | |
| 3168 | " | " | Garnet, (Allochroite) | 1 | Blandan, Mähren | | |
| 3169 | " | " | Lathanite and Cerite | 1 | Bastuas, Sweden | | |
| 3170 | " | " | Garnet, Black Circular aggregations | 1 | East Rock, N. Haven, Ct. | | |
| 3171 | " | " | Cobaltite | 4 | Tunaberg, Sweden | | |
| 3172 | " | " | Cassiterite | 1 | Duluth, Minn., Com. Engl. 1,960 ft. | | |
| 3173 | " | " | Allanite | 1 | Virginia (?) | | |
| 3174 | " | " | Argentite | 1 | Freiberg, Saxony | | |
| 3175 | " | " | Octahedrite, (Anatase) | 1 | Tavetsch, Switzerland | | |
| 3176 | " | " | Pitchstone, (Peclistein) | 1 | Garsbach, Mähren | | |
| 3177 | " | " | Senarmontite | 1 | Ain Babouches | | |
| 3178 | " | " | Alunogen, (Keramohalite) | 1 | Schemnitz, Hungary | | |
| 3179 | " | " | Tourmaline, (Indicolite and Rubellite) & Lepidolite | 1 | Roznend, Mähren | | |
| 3180 | " | " | Zoisite | 1 | Bedazzo, Tyrol | | |
| 3181 | " | " | Orpiment | 1 | Lucky-boy Mine, Utah | | |
| 3182 | " | " | Silver, (Native) | 1 | Mexico | | |
| 3183 | " | " | Opal, (Hyalite var.) | 1 | Waltsch, Mähren | | |
| 3184 | " | " | Rhodocrosite | 1 | Kapnik, Hungary | | |
| 3185 | " | " | Iolite | 1 | Haddam, Conn. | | |
| 3186 | " | " | Serpentine, (pseudo after Feldspar) | 1 | Fassenthal, Tyrol | | |
| 3187 | " | " | Meionite | 1 | Mount Vesuvius | | |
| 3188 | " | " | Barite | 1 | Hungary | | |
| 3189 | " | " | Hydromagnesite, (Lancasterite) | 1 | Texas, Lancaster Co., Pa. | | |
| 3190 | " | " | Dufrenite | 1 | Binnenthal, Switzerland. | | |
| 3191 | " | " | Orpiment | 1 | Felsobanga, Hungary | | |
| 3192 | " | " | Quartz | 1 | Brazil, S. A. | | |
| 3193 | " | " | Wollastonite | 1 | Pzilowa, Banat | | |
| 3194 | " | " | Tetrahedrite, ("Falertz") | 1 | Kapnik, Hungary | | Fine Crystals. |

## *Catalogue of Specimens Registered in the General Museum in* 1879.—Continued.

| Serial Number. | OBTAINED. | | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| | When. | Whence. | | | | | |
| 3195 | 1879. | Geo. F. Kunz | Copper Ore, (Argentiferous) | 1 | Arizona | | |
| 3196 | " | " | Mendozite, ("Alum") | 1 | Centennial Exposition | | Made from Cryolite |
| 3197 | " | " | Quartz, (Bloodstone) | 1 | India | | |
| 3198 | " | " | Apatite, ("Spargelstein") | 1 | Zoptan, Mähren | | |
| 3199 | " | " | Apatite | 1 | Bob Lake, Canada | | |
| 3200 | " | " | Penninite and Garnet | 1 | Zermath, Tyrol | | |
| 3201 | " | " | Alabanite, ("Mangan-blende") | 1 | Magyag | | |
| 3202 | " | " | Arragonite | 1 | Ball's Cave, Schoharie Co., [N.Y. | | |
| 3203 | " | " | Cerussite | 1 | Southampton, Mass | | |
| 3204 | " | " | Apatite, ("Phosphorite") | 1 | Limburg, Nassau | | |
| 3205 | " | " | Realgar | 1 | Kapnik, Hungary | | |
| 3206 | " | " | Anorthite—After Feldspar | 1 | Tyrol | | |
| 3207 | " | " | Molybdenite | 1 | Zinnwald, Bohemia | | |
| 3208 | " | " | Stilpnomelane | 1 | Baern, Bohemia | | |
| 3209 | " | " | Antillite, (impure Serpentine) | 1 | Cuba | | |
| 3210 | " | " | Hatchittite | 1 | Bologne, Italy | | |
| 3211 | " | " | Chalcocite | 1 | Bristol, Conn | | |
| 3212 | " | " | Sepiolite, (Meerschaum) | 1 | Mähren | | |
| 3213 | " | " | " " | 2 | Schubenka, Turkey | | |
| 3214 | " | " | Albite, (Pericline) | 1 | Models, Switzerland | | |
| 3215 | " | " | Ulexite, (Pricexite) | 1 | Curry Co., Oregon | | |
| 3216 | " | " | Pinite, (Liebenerite) | 1 | Piccinega, Tyrol | | |
| 3217 | " | " | Astrophyllite | 1 | El Paso Co., Col | | |
| 3218 | " | " | Chalcocite | 1 | Bristol, Ct. | | |
| 3219 | " | " | Danalite with Annite | 1 | Rockport, Mass. | | |
| 3220 | " | " | Petzite and Altaite | 1 | Colorado | | |
| 3221 | " | " | Orthite and Yttrotantalite | 1 | Ytterby, Sweden | | |
| 3222 | " | " | Obsidian | 1 | Mexico | | |
| 3223 | " | " | Breithauptite | 1 | Andreasburg, Harz Mts. | | |
| 3224 | " | " | Turnerite | 1 | St. Brigetta, Switz | | |

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|---|---|---|---|---|---|---|---|
| 3225 | 1879. | Geo. F. Kunz | Iodyrite | 2 | Caracoles, Chili | | |
| 2226 | " | " | Mica, (Blumoce) | 1 | New York City | | |
| 3227 | " | " | Bromyrite | 1 | Caracoles, Chili | | |
| 3228 | " | " | Pyroxene, (Fassaite) | 1 | Fassenthal, Switz | | |
| 3229 | " | " | Ardennite | 1 | Salm Chateau, Bel | | |
| 3230 | " | " | Lazulite | 1 | Krieglach, Steirmath | | |
| 3231 | " | " | Yttrotantalite | 1 | Ytterby, Sweden | | |
| 3332 | " | " | Genthite, (Noumeite) | 1 | Victoria, Aust | | |
| 3233 | " | " | Cerargyrite, (In Plates) | 1 | Caracoles, Chili | | |
| 3234 | " | " | Croesite | 1 | Beresof, Siberia | | |
| 3235 | " | " | Uraninite, (Pitch-blende) | 1 | Prizbrau, Bohemia | | |
| 3236 | " | " | Binnite | 1 | Binnenthal, Switz | | |
| 3237 | " | " | Allanite, (Orthite) | 1 | Arendal, Norway | | |
| 3238 | " | " | Scorodite | 1 | Westphalia | | |
| 3239 | " | " | Torgite | 1 | Sehrbach, Herz | | |
| 3240 | " | " | Scheelite | 1 | Zinnwald, Bohemia | | |
| 3241 | " | " | Pyrochlore | 1 | Miask, Ural | | |
| 3242 | " | " | Alunite | 1 | Mienes (?), Hungary | | |
| 3243 | " | " | Cassiterite | 1 | Zinnwald, Bohemia | | |
| 3244 | " | " | Orthoclase, (Chesterlite) | 1 | Chester Co., Penn | | |
| 3245 | " | " | Heulandite | 1 | Nova Scoiia | | |
| 3246 | " | " | Zoisite | 1 | Alvater, Mähren | | |
| 3247 | " | " | Heulandite | 1 | Nova Scotia | | |
| 3248 | " | " | Pyroxene, (Pilkarandite) | 1 | Pilkarauda, Finland | | |
| 3249 | " | " | Pihlite, ("Cymatolite") | 1 | Goshen, Mass | | |
| 3250 | " | " | Vesuvianite, (Idocrase) | 1 | Fassenthal, Tyrol | | |
| 3251 | " | " | Cerargyrite | 1 | Caracoles, Chili | | Fine crystals |
| 3252 | " | " | Yttrotantalite | 1 | Arendal, Norway | | |
| 3253 | " | " | Malachite | 1 | Russia | | |
| 3254 | " | " | Pyroxene (Coccolite) | 1 | Amity, N. Y | | |

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|---|---|---|---|---|---|---|---|
| 3255 | 1879. | Geo. F. Kunz | Bournonite and Chalcopyrite | 1 | Felsobanga, Hungary | | |
| 3256 | " | " | Amphibole, (Actinolite) | 1 | Arendal, Norway | | |
| 3257 | " | " | Malachite, (Crystals) | 1 | Westphalia | | |
| 3258 | " | " | Copper Ore—Argentiferous | 1 | Arizona | | |
| 3259 | " | " | Orthoclase, (Adularia) | 1 | St. Gothard | | Fine large crystals. |
| 3260 | " | " | Jordanite | 1 | Binnenthal, Switz | | |
| 3261 | " | " | Hematite, (Martite) | 1 | Digby, Mich | | |
| 3262 | " | " | Chloritoid | 1 | Smithfield, Rd. Id | | |
| 3263 | " | " | Cryophyllite and Orthoclase, (Amazon-stone) | 1 | Rockport, Mass | | |
| 3264 | " | " | Oligoclase and Kjerulfine | 1 | Brevig, Norway | | |
| 3265 | " | " | Smaltite, (Speiskobalt) | 1 | Dobshau, Mähren | | |
| 3266 | " | " | Cerargyrite | 1 | Caracoles, Chili | | |
| 3267 | " | " | Garnet, (Essonite) | 1 | Tyrol | | |
| 3268 | " | " | Orthoclase, (Lexoclase) | 1 | Bloomingdale, N. J | | |
| 3269 | " | " | Quartz | 1 | Nova Scotia | | Having a fused appearance. |
| 3270 | " | " | Pyrargyrite | 1 | Kapnik, Hungary | | |
| 3271 | " | " | Wolframite | 1 | Zinnwald, Bohemia | | |
| 3272 | " | " | Lazulite | 1 | Matterhorn, Switz | | |
| 3273 | " | " | Apophyllite, (?) | 1 | Aussig, Bohemia | | Labeled Albin by Kunz. |
| 3274 | " | " | Aemite | 1 | Arendal, Norway | | Crystals occurring in Beryl |
| 3275 | " | " | Wallongongite | 1 | Wallongong, Aus | | |
| 3276 | Dec., 1878 | G. F. Townsend | Granite, (red) | 1 | Red Beach, Me | | Presented by George F. Townsend |
| 3277 | Sept., 1879 | Regent Chute | Calcite and Pyrites, Geode of Pyrite on Calcite in impure limestone | 1 | Taylor's Falls | | |
| 3278 | " | Geol. Survey | Doleryte, ("Rice Pt. Granite") | 1 | R. R. Depot, Duluth | | C. W. Hall. |
| 3279 | " | " | Feldspar | 1 | Summit of Carlton's Peak | | " " |
| 3280 | " | " | " | Indf | Beaver Bay, L. Sup | | " " |
| 3281 | Dec., 1879 | J. S. Clark, | Gold, (free gold in Quartz) | 3 | Goldenville, Guysboro Co., N. S. | | Presented by J. S. Clark, |

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|---|---|---|---|---|---|---|---|
| 3282 | 1879. | Geol. Survey | Peat | 1 | Minnesota | | N. H. Winchell, |
| 3283 | 1876. | Cen. Exhibition | Coal Dust Utilized | 2 | | | Presented by Anthracite Fuel Co., Rondout, N. Y. |
| 3284 | 1879. | Geol. Survey | Red Quartzyte | 2 | Near New Ulm | Potsdam | W. Upham, Meierding's Quarry. |
| 3285 | " | " | " " | 3 | Near New Ulm | " | " " From N. W. part of outcrop. |
| 3286 | " | " | Gneiss | 2 | Little R'k, n'r Ft. Ridgely | | W. Upham. |
| 3287 | " | " | Granite | 2 | Little R'k, n'r Ft. Ridgely | | " " |
| 3288 | " | " | " | 3 | Little R'k, n'r Ft. Ridgely | | " " 10 feet from Gneiss |
| 3289 | " | " | Green Sandrock | 1 | Habron, Nicollet Co | | " " From the tail-race below mill. |
| 3290 | " | " | St. Lawrence Limestone | 1 | Hebron, Nicollet Co | | " " South quarry of Mrs. Dunham. |
| 3291 | " | " | " " | 2 | Hebron, Nicollet Co | | " " S. E. quarry of Mrs. Dunham. |
| 3292 | " | " | " " | 2 | Hebron, Nicollet Co | | " " Phillips quarry. |
| 3293 | " | " | " " | 4 | St. Lawrence | | " " Bisson's quarry. |
| 3294 | " | " | Shakopee " | 5 | Louisville, Scott Co | | " " Mrs. Spencer's quarry. |
| 3295 | " | " | " " | 1 | Louisville, Scott Co | | Mrs. Spencer's. lower layers. |
| 3296 | " | " | " " | 7 | Opposite Mankato | | W. Upham, Marsh's quarry. |
| 3297 | " | " | " " | 1 | Opposite Mankato | | " " 1 foot above Jordan sandstone. |
| 3298 | " | " | " " | 2 | Park Prairie | | " " "Linter." |
| 3299 | " | " | " " | 1 | Park Prairie | | " " "Osbornes." |
| 3300 | " | " | " " | 3 | Park Prairie | | " " "Linter." |
| 3301 | " | " | Jordan Sandstone | 2 | St. Peter | Jordan | " " Concretions 10 ft. below top. |
| 3302 | " | " | Red Shale | 3 | St. Peter | Shak | " " at Base of Shak. |
| 3303 | " | " | Limonitic Sandrock, (Magnesian) | 1 | St. Peter | Jordan | " " under No. 3302. |
| 3304 | " | " | Shakopee Limestone | 5 | St. Peter | Shak | " " Asylum quarry. |

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|---|---|---|---|---|---|---|---|
| 3305 | 1879. | Geol. Survey | Shakopee Limestone | 5 | Lousisville | Shak | W. Upham, Contre's quarry. |
| 3306 | " | " | Red Shale | Indf | Courtland | Cret. | " " Heyman's Limekiln. |
| 3307 | " | " | Niobrara Limestone | 2 | Courtland | " | " " " " |
| 3308 | " | " | White Shale | 2 | Courtland | " | " " " " |
| 3309 | " | " | Greenish Clay | 1 | Courtland | " | " " " " |
| 3310 | " | " | Dakota Sandstone | 1 | Courtland | " | " " Greenholz quarry. |
| 3311 | " | " | " Conglomerate | 1 | Courtland | " | " " " " |
| 3312 | " | " | " Sandstone | 2 | Courtland | " | " " Fritz's quarry. |
| 3313 | " | " | " " Concretionary | 1 | Courtland | " | " " " " |
| 3314 | 1877. | " | Drillings from Bottom of Deep Well | .... | Herman | | N. H. W. |
| 3315 | 1878. | " | Shark's Teeth—Hemipristis serrata, Ag. | 22 | Charleston, S. C | Eocene | A. W. Vogdes. |
| 3316 | " | " | " " Galiocerdo contortus, Ag | 29 | Charleston, S. C | " | " |
| 3317 | " | " | " " Oxyrhiria plicatilis, Ag | 1 | Charleston, S. C | " | " |
| 3318 | 1880. | Dr. Riheldaffer | Iron Pyrites | 1 | Pennsylvania | Coal Meas. | Presented by Dr. J. H. Riheldaffer. |
| 3319 | 1879. | Geo. F. Kunz | Zinc Hausmannite, (Helaerolite) | 1 | Ogdensburg, N. J | | |
| 3320 | " | " | Haferite | 1 | Iserlohn, Westphalia | | |
| 3321 | " | " | Ludergite | 1 | Banat, Hungary | | |
| 3322 | Jan. 30, '80 | Prof. T. Egleston | Cuprite, (Chalcotrichite) | 1 | Copper Falls Mine, Mich. | Conglom | By Exchange. |
| 3323 | " | " | Columbite | 4 | Chesterfield, Mass | | " |
| 3324 | " | " | Zircon, (Œrstedite) and Aglaite | 5 | Chesterfield, Mass | | " containing 4 per ct. of Uranium. |
| 3325 | " | " | Delessite | 3 | Copper Falls Mine, Mich. | | " |
| 3326 | " | " | Enstatite | 1 | St. Etienne, Styria | | " |
| 3327 | " | " | Martite | 5 | N. York mine, L. Sup | Huronian | " Pseudomorph after magnetite. |
| 3328 | " | " | Allanite | 1 | Port Henry, N. Y | | " |
| 3329 | " | " | Allanite | 3 | Edenville | | " |
| 3330 | Feb., 1880 | Geol. Survey | Conularia Trentonensis | 1 | Minneapolis | Trenton | Presented by C. E. Chatfield, Esq. |
| 3331 | Aug., 1878 | " | Thomsonite | Indf | Eclipse Beach, L. Sup | Cuprif. | |
| 3332 | " | " | " (Lintonite) | " | Eclipse Beach, L. Sup | " | |

## *Catalogue of Specimens Registered in the General Museum in* 1879—Continued.

| Serial Number. | OBTAINED. When. | OBTAINED. Whence. | NAME. | No. of Specimens. | Locality. | Formation. | Collector and Remarks. |
|---|---|---|---|---|---|---|---|
| 3333 | Aug., 1878 | Geol. Survey | Thomsonite | Indf | Terrace Pt. | Cuprif | N. H. Winchell (of T. Mayhew.) |
| 3334 | " | " | " (Lintonite) | " | Terrace Pt. | " | " " |
| 3335 | July, 1879 | " | " | " | Terrace Pt. | " | N. H. Winchell. |
| 3336 | " | " | " (Lintonite) | " | Terrace Pt. | " | " |
| 3337 | Aug., 1879 | " | " (?) | " | N. shore of Isle Royale | " | " |
| 3338 | " | " | Chalcocite | .... | St. Croix Falls, Wis. | " | " |
| 3339 | Dec., 1879 | J. Lawrence Smith | Meteoric Stone—Fell June 15, 1821 | 1 | Jurenas, France | | By Exchange with J. Law. Smith. |
| 3340 | " | " | " " Fell May 14, 1834 | 1 | Orgueil, France | | " " |
| 3341 | " | " | " " Fell October 13, 1838 | 1 | Cold Bokkevald, Cape of Good Hope, Africa | | " " |
| 3342 | " | " | " " | 1 | Waconda, Kansas | | " " |
| 3343 | " | " | " " | 1 | Cynthiana, Ky | | " " |
| 3344 | " | " | Meteoric Iron | 1 | Caanbourm, Australia | | " " |
| 3345 | " | " | Native Iron—In composition somewhat like Meteoric Iron | 2 | From the basalt, Ovifach, Greenland | | " " |
| 3345 | " | " | Meteoric Iron | 1 | Sevier Co., Tenn | | " " |
| 3346 | " | " | " Stone | 1 | Warren Co., Mo. | | " " |
| 3347 | " | " | " Iron | 1 | Carthage, Smith Co., Ten | | " " |
| 3348 | " | " | Daubreelite—From Meteoric Iron | 1 | Coahuila, Mex | | " " |
| 3349 | " | " | Meteoric Stone—Fell June 9, 1866 | 1 | Kuyahinya, Hungary | | " " |
| 3350 | " | " | " Iron | 1 | Babb's Mill, Green Co., Ten | | " " |
| 3351 | " | " | " Stone—Fell June 30, 1868 | 1 | Pultusk, Poland | | " " |
| 3352 | " | " | " " Fell May 9, 1827 | 1 | Drake Creek, Tenn. | | " " |
| 3353 | " | " | " Iron | 1 | Casey Co., Kentucky | | " " |
| 3354 | " | " | " " | 1 | Murfreesboro, Tenn | | " " |
| 3355 | " | " | " " | 1 | Robertson Co., Tenn | | " " |
| 3356 | " | " | " " | 1 | Bates Co., Mo. | | " " |
| 3357 | " | " | " " with Daubreelite in Troilite | 1 | Coahuila, Mex | | " " |
| 3358 | " | " | " Stone—Fell February 12, 1875 | 1 | Iowa City, Iowa | | " " |
| 3359 | " | " | " Iron | 1 | Near Milwaukee, Wis | | " " |
| 3360 | " | " | " " (weighs 6¾ pounds) | 1 | Coahuila, Mex | | " " |

# IV.

# PALÆONTOLOGY.

*Descriptions of New Species of Brachiopoda from the Trenton and Hudson River Formations in Minnesota.*

BY N. H. WINCHELL.

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GENUS **Lingula,** (Bruguiere.)

(Encyc. Meth. I. tab., 250.

*Gen. Char.*—Sub-equivalve, equilateral, longitudinally ovate or sub-pentagonal, both valves channelled equally at the beaks for the passage of the pedicle (one beak a little longer and more pointed than the other, which latter has a narrow internal flat area;) internally each valve has a thickened pad in the middle, and the shorter one has in front of it a prominent internal septum. The species of the genus grow wider proportionally with age. (McCoy, *Brit. Pal. Foss.*)

This genus has been regarded as one of the few living forms that began their existence among the earliest marine inhabitants of the globe, (*Pal. N. Y.*, Vol. I, p. 94) but, according to Prof. James Hall, it is "extremely doubtful whether we have yet evidence to claim the occurrence of a single species of true *Lingula* in the lower palæozoic rocks," (23*rd Reg. Rep.*, p. 245.) The older Linguloid forms in the Potsdam sandstone have been distributed, at least provisionally, among the new genera *Lingulella* (Salter,) *Lingulepis* (Hall,) *Obolella* (Billings,) and *Lingulops* (Hall.) These bracheopods have fragile phosphatic valves, a circumstance which has served to preserve their lustre in many cases where the exterior of the shell is exposed freshly, and to prevent their

absorption into the rock. They are easily distinguishable from the other genera of brachiopods found in the Trenton Group of rocks. Until more definite information is obtained of the differences and distinctions among the above-mentioned new genera, it will be admissible to place them all under the old term so far as they occur in the Trenton Group.

**Lingula Minnesotensis.** (*N. sp.*)

*Reference and Synonymy.*—Lingula quadrata, *Winchell*, Geol. and Nat. Hist. Survey, Annual Report for 1875, p. 49; also *ibid* for 1876, p. 54, 215; also *ibid* for 1877, p. 164.

Shell sub-quadrate or oblong, the sides nearly straight and parallel, but with a little convexity; the anterior angles rounded, the sides passing into the posterior lateral edges with a uniform curvature; the beak of one valve projecting beyond the other; the shorter valve more elevated and tumid than the larger, both transversely and longitudinally; on the exfoliation of the shell each side of the cast shows a central furrow extending from the beak about three-fourths the length of the shell; in front of the postero-lateral margins is a somewhat depressed space on either side of the beak, and on either valve, the convexity of the valves rising more rapidly at a short distance from the margins; this depression along the posterior angles gradually disappears as the central elevated area widens toward the front.

Although the true surface of the shell is generally exfoliated, on the interior casts are concentric, broad plications of growth. These are crossed, at least along their central front, by longitudinal radiations. Along the depressed postero-lateral margins these concentric plications are crowded and imbricated. Between, and also covering these plications of growth, are fine concentric striæ over the whole surface.

Length nearly ⅞ inch; width a little over ½ inch.

The species resembles *L. Lewisii* (Sow.) but has not the straight postero-lateral margins (*Brit. Pal. Foss.* p. 253.) It also resembles *L. quadrata,* (Eich.) but is but little more than one-half the size of that, and the difference in the convexity of its valves is greater.

In the report for 1875 this species was identified as *L. quadrata* (Eich.) at Taylor's quarry near Fountain.

*Locality and Formation.* Olmsted county, (W. D. Hurlbut.) Fountain, Fillmore county, and Wanamingo in Goodhue county.

Minneapolis, associated with *Strophomena deltoidea* (Con.) In the Trenton limestone.

*Collectors.* N. H. Winchell; at Minneapolis H. V. Winchell.

*Museum Register Numbers,* 3499, 3501, (=291,) 3502 (=645,) 3503.*

**Lingula Hurlbuti.** (*N. sp.*)

Shell ovate, broadest in the anterior half, and pointed; the sides approaching the apex with a gentle convexity; lines tangent to sides at one-third the length from the apex, form an angle of seventy-two degrees; anterior angles obsolete. The exterior surface of the shell is marked by sharply elevated concentric plications, which stand perpendicular to the shell, and on the anterior third portion five occupy the space of one line, but toward the beak they are reduced in size and increase in frequency so as to become mere striae. Where these are largest and perfectly developed, the intervening grooves are destitute of fine striations. These plications leave corresponding lines on the interior cast when the shell is exfoliated. There are no longitudinal radiations visible on the exterior, but on the cast near the front are exceedingly dim, interrupted lines visible under the lens, that possibly have the same origin, but these do not extend more than a line and a half from the front margin, and they cannot be seen even with the lens except under a favorable angle of reflected light.

The most elevated portion is at one.third the length from the beak; but the convexity of the valve is moderate and regular.

This species resembles *Lingula Daphne* (Bill,) but exceeds the greatest size of that as given by Mr. Billings (*Pal. Foss.*, p. 50,) by 2½ lines, and is wholly devoid of the fine concentric striæ of that species.

*Locality and Formation.* At Mantorville, in the Galena limestone, collected by N. H. Winchell.

*Museum Register, Number* 393.

Dedicated to Mr. W. D. Hurlbut of Rochester, Minn., one of the earliest patrons of the Geological and Natural History Survey.

* Since the above was written the same species has been published in the American Journal of Science by Mr. R. P. Whitfield, (June 1880,) and named *Lingula Elderi*. His specimens were procured for him by Dr. Elder, of Rochester, where they occur in the Trenton limestone, and exhibit so perfectly the internal markings due to the visceral and muscular structure, that Mr. Whitfield regards the species a true Lingula, comparing it to *Lingula anatina* (Lam.) now living. Priority of publication will require the adoption of Mr. Whitfield's name, which will hereafter be applied to it in the publications of the survey.

GENUS. **Crania.** (Retzius.)

*Gen. Char.*—Attached by the substance of the dorsal valve, which exhibits an irregular scar. The posterior pair of adductor muscles are larger and deeper than the anterior pair.

**Crania granulosa.** (*N. sp.*)

Shell small but prominently elevated at the beak; orbicular, or somewhat widened between the antero-lateral margins; no concentric striæ or undulations visible on the exterior of the shell, nor radiations; the whole surface of the dorsal valve uniformly fine-granulated, or pustulose; these granulations not disposed in any apparent order. The lower valve unknown.

*Locality and Formation.*—Minneapolis, in the Trenton limestone-Collected by C. L. Herrick.

*Museum Number* 708.

GENUS. **Orthis.** (Dalman.)

*Gen. Char.*—Subquadrate or rounded; hinge line rarely equalling the width of the shell; shell radiately striated or plaited; each valve with a triangular cardinal area, and a triangular foramen, generally more or less closed in one valve by a deltidium; dorsal valve with divergent short-teeth, and a simple cardinal process between them.

**Orthis Minneapolis.** (*N. sp.*)

Shell transversely suboval; greater diameter from nine to ten lines, but some of the smaller specimens less than seven; smaller diameter from five to seven lines, but in the smaller specimens about four; hinge-line less than the greater width of the shell, but the cardinal angles are distinct in all cases, and sometimes slightly recurved by the appression of the valves. A shallow, broad sinus depresses the front of the larger valve, which produces a marked geniculation in the front margin, and sometimes an elongation of both valves toward the front. From this sinus the outline of the shell rounds evenly to the cardinal angles. Both valves with a distinct hinge-area, that of the entering valve being about two-thirds the height of that of the receiving, both being somewhat concave transversely, and with triangular foramens. The foramen of the receiving valve is about twice as high as wide, and that of the entering is about equilateral. The beak of the larger valve is small and moderately abrupt, that of the smaller inconspicuous. Both valves are ornamented with fine radiating, striæ, which increase in number by implantation two or three

times between the beak and the margin, remaining of nearly the same size. In some specimens broad, imbricating growth-bands cross these striae near the margin, but even in well-preserved specimens, there is visible under the lens no inter-costal crenulation.

The interior of the receiving valve has two strong ridges that define the margins of the main muscular impression, descending from the cardinal processes curvingly toward the centre of the valve, and terminating, before they unite, in vanishing points at about midway between the beak and the front margin. Between these ridges, and within the area they enclose, rises suddenly in the middle of the valve a straight, sharp ridge that extends toward the front of the valve, cardinal processes tooth-like.

The interior of the entering valve is only partly known. On a single specimen only is preserved a strongly divergent small tooth, with a deep pit separating it from the cardinal area. There seem to be also three (two are preserved) main ridges radiating from the beak, two short ones from the bases of the cardinal teeth, and one longer between them. The impressions of the external radii are visible on the interior margins of both valves. This differs from *Orthis Maria*, (Billings,) which it resembles, in having the front never straight, but rather protruded at the mesial angle, and in the finer radiating striæ, which are from six to eight in one line, at the middle of the front margin, instead of from three to four.

*Formation and Locality.* Hudson River shales at Minneapolis, and at Fountain in Fillmore county.

*Collectors.* N. H. Winchell and C. L. Herrick.

*Museum Register Numbers*, 321, 644, and 737.

**Orthis media.** (*N. sp.*)

Allied to *Orthis Minneapolis*, and at first confounded with that species in the preliminary assortment, is a species that varies from it in outward characters, in having coarser striæ, (and in that respect approaching *Orthis Maria*—Billings,) there being at the front margin four or five of the radiating striæ in the space of one line, and in having a less deep mesial depression on the front of the receiving valve. Along the central portion of the entering valve is usually a flattened area that widens from the beak toward the front, terminating at the mesial angles, and the cardinal angles are sometimes reflected at their extremities. The valves are apt to be displaced and distorted, indicating an insecure dental articulation, but there has been no opportunity to examine

the interior. The triangular foramen of the receiving valve, which is open in all cases, has a height of one line, which is about one-third or one-half greater than that of the entering valve. The radiating striæ double their number in the umbonal region, by implantation, and in the same manner further increase their number near the margin of the valves. They are crossed by growth-bands toward the margin of the shell.

The transverse diameter of this shell varies from seven to nine lines; that from the beaks to the front margin from less than six to less than eight.

*Formation and Locality.* Hudson River shales, at Minneapolis. Collected by C. L. Herrick.

*Museum Register Number* 3514.

**Orthis Kassubæ.** (*N. sp.*)

Shell transversely oblong, with a hinge-line terminating in distinct cardinal angles, but less than the greatest transverse diameter of the shell: outline evenly rounded through the front from the cardinal angles, but having a broad, gentle inclination toward the side of the entering valve along the front margin; valves closely appressed about the free margins, but having a thickness through the umboes from 2¾ to 3½ lines; height of the larger foramen about ¼ the length of the hinge-line, and about ¼ greater than its width at the base; cardinal areas somewhat concave, but the beaks are far separate, that of the receiving valve being less extended posteriorly than the other, though more elevated and more abrupt; the plain of the cardinal area of the entering valve, which is in the plain of the sides of the shell, forms an angle greater than 90° with that of the receiving valve.

Surface marked by fine radiating costæ which bifurcate once or twice between the beaks and the free margins, none of them running out on the hinge-line, there being from six to eight in the space of one line in the middle of the front. Interior unknown.

*Locality and Formation.* Minneapolis, in the Hudson river shales.

*Collector.* N. H. Winchell.

*Museum Register Numbers,* 336 and 643.

Named from Mr. Charles Kassube of Minneapolis, whose collection contains the most perfect specimen seen.

**Orthis amœna.** (*N. sp.*)

Shell transversely oval with a hinge line that compares to the greatest diameter about as 5 to 9. Evenly rounded from the car-

dinal extremities, which hardly disturb the symmetry of the outline, through the front margin; valves nearly equal; umbonal region of the receiving valve surrounded by a depressed or somewhat concave border, which in the front margin becomes flat or inclines toward the entering valve; the entering valve having much less marginal concavity, but being moderately and evenly convex; cardinal areas small; foramens also small; beak of the receiving valve somewhat incurved; that of the entering valve small, but abrupt and distinct; surface marked by rays which are doubled or tripled in number on the umbo, by implantation, but maintain a larger size than the rest in passing to the margins, several of which are also curved so as to run out on the hinge-line; transverse diameter 9 to 10 lines; perpendicular diameter from 7½ to 8½ lines. Interior unknown.

*Locality and Formation.* Spring Valley, in the Galena beds of the Hudson River Formation.

Collected by N. H. Winchell.

*Museum Number* 642.

**Orthis circularis.** (*N. sp.*)

Shell sub-circular, the greatest diameter being from just in front of one cardinal angle to the antero-lateral margin on the opposite side; hinge-line about one-half the greatest diameter; along the front margin is a very slight inclination toward the smaller valve, but the valves are otherwise uniformly convex; umbo of the receiving valve prominent and full, but the beak low and arched over the cardinal area; the other valve less elevated in the umbo, and the beak less prolonged, but slightly incurved over the hinge-line; the open foramen of the receiving valve long and narrow, with an obtuse apex, but two or three times as wide at the base as at the top; surface marked by numerous fine rays, which, bifurcating once or twice between the umbo and the free margin, are sub-equal at the middle of the front margin, and number six or seven in the space of one line, two or three curving backward from the beak and terminating on the hinge-area. These rays are crossed by fine concentric lines, only visible in fresh specimens and under a magnifier, and by distant dim growth-bands, which latter begin on the umbo; diameter about half an inch. Interior unknown.

*Locality and Formation.* Oxford Mills, near Canon Falls, in Goodhue county, in the Hudson River shales.

*Collector.* N. H. Winchell.

*Museum Register Number* 3515.

**Orthis Charlottæ.** (*N. sp.*)

Of this species the only specimen seen is a perfect receiving valve.

This valve is transversely oval, or suborbicular, with a hinge-line less than two-thirds the greatest diameter, and with inconspicuous cardinal angles; moderately and uniformly convex, but with a broad undefined flattening along the central front, which extends about one-third the distance toward the beak and insensibly passes into the general convexity; beak distinct, and elevated above the hinge-line one line and a half, making angles with the posterior third of the plain of the lateral margins, of 102° and 78°, the former being within the valve and the latter behind the cardinal area; cardinal area nearly straight, the ventral teeth forming inward projections on the hinge-line; the foramen triangular, with a width at the base nearly the same as the height; exterior marked by 22-24 coarse, undivided, rounded, radiating plications of the shell, two or three of which on each side of the beak, rather terminate, or subside, on the hinge-line; these plications crossed by imbricating growth-bands, some of which are very fine, and some coarse; the intervening inward plications being of the same width, but on the interior of the shell presenting a very different aspect, by having each a central furrow or trough and thus appearing double.

The interior of the valve shows the grooved inward plications of the shell extending, along the front, nearly half way toward the beak, along the lateral margins much less, and disappearing wholly toward the cardinal angles, but in all cases extending within the visceral area, in the form of faint ridges or striations which increase in number toward the center of the shell; brachial processes stout, trigonal, truncato-concave on their extremities; muscular impression rather narrow and small, bilobate, defined by a marginal ridge which is much more distinct posteriorly, and converging at an angle of 20°, and confluent with the brachial processes, extending to within one line of the center of the valve; adductor and divaricator scars confluent; a short, distinct, keel-like, mesial ridge extending from the sinus formed by the lobes toward the center of the general muscular scar, where it is suddenly succeeded by a central depression which contracts to the beak, bounded by distinct ridges and having a slight central elevation; ventral adjustor scars outside the brachial processes and coarsely striated transversely. Transverse diameter 11 lines, perpendicular about 10 lines.

The dorsal valve is unknown.

This species differs from *O. callactis* (Dal.) by not having both valves greatly depressed, and in having 22–24 ribs instead of 16–20.

It differs from *O. Actoniæ* (Sow.) in not having a cardinal line equal to the width of the shell, nor acute cardinal angles, nor an incurved ventral beak, nor 11–20 angular ribs.

It differs from *O. calligramma* (Dal.) in not having a prominent beak in the receiving valve incurved nearly to the level of the lateral margins. (McCoy.)

It differs from *O. flabellulum* (Sow.) in not having a flat receiving valve, and in not having the dental lamellae of the receiving valve diverging at an angle of 85°. (McCoy.)

It differs from *O. pectinella* (Conrad) in not having a flat receiving valve. (Hall.)

Mr. Salter, in the *Memoirs of the British Geological Survey*, Vol. II, part 1, p. 374, has assayed to include under the general specific name of *O. calligramma* not only the *calligramma* of Dalman, but also his *callactis*, Sowerby's *virgata* and *rustica* and *Spirifer plicatus*, Von Buch's *ovata* and *orthambonites* (after de Verneuil,) Davidson's *Walsalli* and *rigida*, and a number of species of Pander, but recognizing seven varieties. Admitting this combination, and comparing the species under consideration with his general specific description, it is found to differ from it in not having squarish ribs and square furrows equal to the ribs, nor a rhomboidal muscular impression in the ventral (receiving) valve, divided by a broad faint ridge; yet it may be that Mr. Salter's description may be legitimately modified and extended so as to cover this form also.

*Locality and Formation.* Minneapolis, in the Hudson River shales.

Collected by C. L. Herrick.

*Museum Register Number* 667.

### Orthis Conradi. (*N. sp.*)

Shell having the shape and size of *Orthis disparilis* (Con.) but with a moderately convex entering valve, with from fifty to sixty fine radiating striæ on each valve, about half of which disappear before reaching the beak; foramen of the larger valve narrow, of the smaller valve triangular; surface with indistinct growth-bands, but without evident interradial crenulation; on the center of the smaller valve is a flattening that widens from the beak, and disappears before reaching the margin.

*Orthis disparilis*, according to Conrad's original description

(*Proc. Acad. Nat. Sci., Phil.*, 1843, *Vol. I, p.* 333,) has "about twenty-eight prominent, rounded, regular ribs," and the lesser valve slightly concave, with a depressed furrow in the middle. Prof. Hall adds to this by saying (*Pal. N. Y., Vol. I, p.* 119) the ribs are "crossed by finer, concentric, elevated lines," and that the foramen is a narrow, nearly linear slit reaching to the apex; but subsequently he and Mr. R. P. Whitfield concurred in the opinion that Conrad's *O. disparilis* is the young of *Orthis tricenaria*, (Con.) (*Pal. of Ohio, Vol. II, p.* 78), especially as they both come from the Trenton limestones of western Wisconsin; and the figures of this species in the Palæontology of New York seem to bear out this view. Mr. Billings, in the *Canadian Naturalist and Geologist* for 1859, Vol. IV, figures this species from the Chazy with a "nearly flat dorsal valve, and about twenty-eight rounded, undivided ribs." At the same time he describes from the Chazy limestone *Orthis Porcia,* which differs from *O. disparilis* "in having the radiating ridges not so strong," in its "fine, strongly imbricated, concentric striæ" and "more perpendicular area" in the receiving valve, the dorsal valve being unknown.

The species under consideration differs essentially from all the foregoing, and is certainly not the young of *Othis tricenaria,* since, although both occur at Minneapolis, this is from the Hudson River Shales, while *O. tricenaria* is found in the subcrystalline layers of the upper portion of the Trenton, usually in the from of interior casts.

*Formation and Locality.* Hudson River Shales at Minneapolis, and in the shales accompanying the upper portion of the Trenton at Fountain in Fillmore county.

*Collectors*—N. H. Winchell and C. L. Herrick.

*Museum Register Numbers* 651 and 789.

# V.

# PRELIMINARY REPORT

ON THE

# GEOLOGY OF CENTRAL AND WESTERN MINNESOTA.

BY WARREN UPHAM.

---

The area here to be described was explored during the summer and autumn of 1879. It lies on the west side of the Mississippi river, and has this stream for its border 30 miles along the north-east side of Wright county. At Clearwater, 60 miles north-west from Saint Paul, the north-east boundary of this area leaves the river and runs west 50 miles, to the south-east corner of Pope county; whence it extends 120 miles due north, to the north-east corner of Becker county, five miles south-west from Itasca lake. The northern limit of this exploration is a line drawn from the last point 78 miles west, to the Red River of the North, which it strikes 19 miles north from Moorhead and Fargo. On the west the boundary is that of Minnesota for 130 miles, following up Red and Bois des Sioux rivers and along Traverse and Big Stone lakes. On the south-west it is the Minnesota river in its south-east course from Big Stone lake to its northward bend at Mankato, 140 miles; this limit, however, being crossed so far as to include both sides of the trough-like valley in which this river flows. Thence the border is at the east side of Le Sueur, Scott, Carver, and Wright counties; reaching 75 miles from south to north. The extreme length of this area is 250 miles, this being parallel with the upper part of the Minnesota river, its south-west boundary; while its average width is about 65 miles. It thus embraces approximately 16,000 square miles, or one-fifth of the State.

In their order from north-west to south-east, the twenty-two counties included in the field of this report, are as follows: Clay, Wilkin, Traverse, Becker, Otter Tail, and Grant, principally drained by the Red river; Big Stone, Swift, Chippewa, Renville, Nicollet, Sibley, Carver, and Scott, bordering Minnesota river; with Stevens, Douglas, Pope, and Kandiyohi, also drained in large part into this river; and Meeker, McLeod, and Wright, drained principally by the Crow river, which joins the Mississippi at Dayton. The exploration of the topography and geology of this large tract within a single year has been made possible by the similarity of contour and the great extent and depth of its drift deposits, and by the very narrow limits

within which the underlying ancient rocks are exposed. These exposures have been found, with one exception, only along the bottom of the valley of Minnesota river, and in the valleys of a few of its tributaries, near their mouths, where channels 100 to 200 feet deep have been excavated in the drift.

### TOPOGRAPHY.

The greater part, probably three-fourths, of this area has a *moderately undulating surface*, which lies in broad swells of various extent, height and direction, some of them prolonged, but generally without any uniformity in trend, while others are oval or nearly round. The highest portions of adjoining undulations vary from a few rods to a half mile or more apart; and their elevation is sometimes 5 to 15 feet, again 20 to 30, or even 40 feet or more, above the depressions, to which the descent is usually by very gentle slopes. These hollows have a contour that is like that of the swells inverted, being mostly wide, and either in long and often crooked courses, of unequal depth, variously branched and connected one with another, or in basins from one to one hundred acres in extent, which have no outlet but are surrounded by land 5 feet or perhaps 10, 20, or 30 feet higher upon all sides. The small swamps which fill these depressions are called *sloughs* or *marshes*, the former name being most in use upon the prairies. Many other depressions, which differ from the foregoing only in their greater depth or area, contain bodies of water, which vary from a few hundred feet to five or ten miles in length. All these are called *lakes;* and the term *pond*, which would be applied to these in the north-eastern United States, is here restricted to reservoirs made by dams.

*Glacial Origin of Superficial Deposits and Contour.* The portions of the earth upon which natural lakes abound are further characterized by surface deposits of clay, sand, gravel, and boulders, mixed together in the same mass, which is called till, boulder-clay, hardpan, or unmodified drift. The rock-fragments are of very diverse material and origin, having been gathered from ledges that are in place in widely separated districts. The direction in which these boulders and pebbles have been carried is from north to south, or to the south-east or south-west, throughout the northern United States and in adjoining British territory. In these and all other drift-covered regions the bed-rocks are marked by parallel scratches and furrows, called striæ, that run in the direction in which the boulders have been transported. The glaciers of the Alps and of Greenland show us such markings and similar deposits of drift now in process of formation; and there are no other known agencies capable of producing these effects. It is therefore a necessary conclusion that the last period in the geological history of this region brought a very cold climate in which a vast ice-sheet was accumulated, each year adding something to its depth by the excess of snowfall over what could be removed by melting and evaporation. Its greatest thickness was far at the north, where the solid ice probably became several miles deep; and the pressure of this vast weight caused it to flow slowly outward in all directions from its deepest part. The superficial materials formed by decomposition of the rocks before this glacial period, were then ploughed up, mingled with large additions by erosion of the underlying ledges, and carried forward in the direction of the ice-current. It appears, also, by shells and trees found deeply buried between glacial deposits, that this very

cold period was not one unbroken reign of ice, but that this retreated and readvanced, or was possibly at some times nearly all melted and then accumulated anew. Thus periods of ice alternated with interglacial epochs, in which animal and vegetable life spread again northward, following close upon the retreat of the ice-fields. By each new advance of the glacial sheet much of the previous surface would be ploughed up and redeposited; hence we find only few and scanty remnants of fossiliferous beds in the glacial drift. At the disappearance of the last ice-sheet these drifted materials, seldom modified by water in their deposition, formed a mantle 100 to 200 feet thick, which throughout the region here described completely covered the solid rocks.

The gently undulating contour of most of this region appears to mark areas over which the ice-sheet moved in a continuous current, and from which it disappeared by melting that was extended at the same time over a wide field. The inequalities of surface are very slight in comparison with the thickness of the drift, and the average height generally rises or falls imperceptibly, its slope being often not more than 50 or 100 feet in as many miles. These general changes in altitude, which affect the whole country and give direction to its drainage, are doubtless produced by differences in height of the bed-rock upon which the drift lies as a sheet, probably somewhat uniform in depth; but the small elevations and depressions appear to be due to the accumulation of different amounts of till in and beneath adjoining portions of the moving ice-sheet. This unequal deposition of the drift has produced the multitude of lakes which dot the map of Minnesota. The lapse of time since the ice-age has been insufficient for rains and streams to fill these basins with sediment, or to cut outlets low enough to drain them; though in many instances we can see such changes slowly going forward.

*Terminal Moraine of the Ice-Sheet.*—The most noticeable deposits of an alpine glacier are its terminal moraine, or the heaps of rock-fragments and detritus which it carries forward to its termination. This frontal line often remains at nearly the same place through many years or centuries. The flowing ice continues to this limit, where it is melted, and the materials which have fallen upon its surface from bordering cliffs, or which it has ploughed up from below, are here left at its end in heaps, ridges and hillocks, of very irregular contour, due to slight retreats and advances of the ice-front, and of greater amount than the deposits which appear upon the area over which it moved, exposed when any climatal change causes the glacier to retreat a considerable distance. Within the field here reported we find similar but much greater accumulations of drift which appear to have been amassed where our last ice-sheet had its termination through a long period. The only notable hills of this area are of this origin. They have no exposures of solid rock, but form part of a belt of rough and hilly drift, where steep slopes and abruptly curving and broken outlines prevail.

This series of hills and rough land extends the whole length of this area, 250 miles; and beyond these limits it appears to be of the same age with a similar belt of hilly drift which has been traced across Wisconsin in the recent geological survey of that state, where it is called the Kettle Moraine. Farther east it is probably represented by similar deposits which cross north-eastern Illinois, thence bend north-eastward into southern Michigan, again

turn to the south and east through Indiana and Ohio, appear in eastern Pennsylvania and northern New Jersey, and have been traced by the writer of this along the north shore of eastern Long Island, through southern Rhode Island, in the Elizabeth islands, and along Cape Cod to its east shore. West of Minnesota our series of hills is continuous, by a loop that reaches into northern Iowa, to the great drift-range which has been called in its south-east portion the Coteau des Prairies and farther north-west the Coteau de Missouri, extending to the North Saskatchewan river, 350 miles west of Lake Winnipeg. These morainic accumulations, traced more than half way across the continent, are thought to mark the line to which the ice-sheet advanced and where it had its termination through the principal part of the last glacial epoch. At a previous period it reached much farther south, carrying its drift somewhat beyond the Missouri river and nearly to the Ohio. The limit of the ice in this earlier epoch was 300 miles south of our terminal moraine.

*Medial Moraines.* Before describing these hills in Minnesota, it is needful to mention that other lines of detritus and boulders, called medial moraines, are formed by alpine glaciers wherever they meet from confluent valleys, thence flowing onward together. Series of drift-hills of like origin are associated with the terminal moraine of the continental ice-sheet, which is found to have its course in long curves, convex toward the south and joined with each other by angles that point northward. The glacial sheet is thus known to have had its front divided in vast lobes, each of which had a diverging current, directed at all sides perpendicularly toward its curved frontal moraine. North from the angle of adjoining ice-lobes their currents pushed against each other, and along this line of confluent ice-fields medial moraines were accumulated, consisting of irregular hills, ridges and mounds of drift, of the same character with those that were formed along the margin of the ice-sheet.

*The moraine in western Minnesota* is partly medial and partly terminal. Beginning beyond the northern limit of our exploration, its course is from the vicinity of Rice lake, near the head of the Wild Rice river, south-south-west 20 miles to the east side of White Earth lake. This portion of the moraine has hills 50 to 100 feet high seen from the top of the new school-building at the White Earth Indian Agency. About this agency the country is prominently undulating, or rolling, having its crests 30 to 40 feet above the lakes which abound. Its general height is about 1600 feet above sea, and this continues to the sources of the Mississippi, 30 miles east. In the next four miles west from White Earth the land descends about 300 feet, to an extensive undulating plain, which has its east boundary at a line running nearly due south 20 miles to the Northern Pacific railroad two miles east of Audubon. Westward this expanse, declining from 1300 to 1200 feet above sea, extends in view from the agency 25 miles, beyond which it again descends 300 feet in three or four miles to the broad lacustrine plain bordering the Red river. The course of the moraine, marked by many small hills of very irregular and broken contour, is due south for its first 30 miles from White Earth lake, passing through the townships of range 40 in Becker county. This belt is crossed by the road from White Earth to Leach lake, which is described as very rough and hilly to the headwaters of Otter Tail river, beyond which it is gently undulating for 50 miles eastward. In the western

two-thirds of Erie and Burlington (139 and 138 of range 40) these hills are finely developed; they rise 50 to 100 feet above the very numerous and irregular depressions, but the general height of the country has fallen off, so that their tops are only 1450 to 1500 feet above sea. Detroit mountain, at the north-east corner of sec. 31, Erie, is one of the highest of these hills. It lies at the west side of their principal belt, which is crossed by the roads from Detroit to Frazee City. On the north road the typical morainic contour is well seen in secs. 7, 8 and 9, Burlington. The coarse unmodified glacial drift, or till, of which our moraine for 250 miles is everywhere made, so far as observed, is here disposed in a great profusion of knolls, short ridges and hills, 20 to 50 feet high.

In Otter Tail county this morainic series continues from the north-west corner of Hobart (t. 137, r. 40,) south-south-west to Spirit lake and Lake Lida, 12 miles. It here varies from one to three miles in width. Its knolls along most of this distance rise only 25 to 50 feet, but they are much more abundant and have steeper and more broken slopes than upon adjoining areas to the east or west. At the south-east side of Lake Lida it forms a range of hills, 100 feet or more above the lake. These are conspicuously seen from the township of Maine, 10 miles south-east. From Lake Lida this moraine widens and covers the first six or seven miles east from the Pelican river, above which it rises 100 to 150 feet or more; being well exhibited for 18 miles in the east portions of Erhard's Grove, Elizabeth, and Fergus Falls. On the road from Maine to Elizabeth its hills are very numerous and irregular in outlines, short, trending from north to south more frequently than in other directions, and separated by hollows 25 to 50 feet deep. Here and for six miles southward, the contour along the Red river and about Wall lake, though within this morainic belt, has been more smoothed than its other portions, probably by floods produced at the withdrawal of the ice-sheet. At Lake Lida these hills have their tops about 1425 feet above sea; thence to the vicinity of Fergus Falls this altitude gradually diminishes to 1300, not because the hills grow smaller, but because the land on which they lie slopes in this direction.

The region west of this moraine, including the south-west corner of Becker county, the south-east part of Clay county, and the west range of townships in Otter Tail county, extending from the Northern Pacific railroad 45 miles south, and as far westward as to the lacustrine basin of the Red River valley, is mainly hilly, with the highest elevations 50 to 100 feet above the hollows. In the east part of Park (t. 138, r. 44,) and perhaps at some other localities, these hills have a typically morainic contour, being plentiful and irregular, small and steep; but generally they are massive and broadly rounded, with long gently curving slopes. Indian hill, in sec. 9, Oscar (t. 134, r. 44,) affords a fine view of part of this area and of the moraine seven miles eastward, while at the west it overlooks the plain of Wilkin county, which stretches with very slight descent 20 miles to the Red river. On the east side of the moraine the only prominent outlying hills are at the south-east corner of Hobart, where a gravelly ridge of irregular contour reaches two or three miles from north to south, its highest portion being about 150 feet above the surrounding country. These are the hills which one sees from Perham, looking north-west.

The greatest development of the moraine within the limits of Minnesota,

is in southern Otter Tail county, where it sweeps in a semicircle from Fergus Falls south-east to the south line of the county and thence east and north-east to East Leaf lake, a distance of 50 miles. In the first 20 miles, or from Fergus Falls to the north side of Lake Christina, at the north-west corner of Douglas county, it is divided into two or three belts of roughly hilly land, with intervening areas of smoother contour. At one to two miles east from Fergus Falls is a narrow belt of irregular hills and hollows, with the crests about 100 feet above the river. This series continues one to three miles wide for 15 miles south-south-east, through Dane Prairie and Tumuli, into the north-east corner of Pomme de Terre township. Next it partly bends east to the high hills north of Pelican lake, and is partly represented by the less irregular but yet prominently hilly land which lies between Pelican and Pomme de Terre lakes and continues thence a few miles farther south. In Dane Prairie and Tumuli this moraine lies at the east side of a series of lakes, of which Swan and Ten Mile lakes are the largest. Beside the latter, in secs. 27 and 34, Tumuli, the contour for a width of one-eighth to one-fourth mile is in very irregular short hills, 25 to 40 feet above the lake. Their trend, north-west to south-east, is parallel with the lake and with the course of the moraine. These small hills are exceedingly rocky with granitic and gneissic boulders of all sizes up to five or six feet in diameter, which frequently cover half of the ground for several rods distance. North-east from this typically morainic line the land for a few miles is in massive hills and swells, which rise 50 to 75 feet above intervening hollows and lakes. Its least hilly portion is St. Olaf township, which has mostly a rolling surface, in extensive swells 30 to 50 feet high. The east part of Tordenskjold is occupied by a second belt of very irregular hills, which is connected through secs. 19 and 20 and the north part of secs. 7 and 8 with the series that lies at the east side of Wall lake and the Red river, reaching north-west to the broad area of this moraine in Friberg and Elizabeth. The Tordenskjold hills are also joined from the north by another line of drift deposits, having a very rough contour in knolls, ridges and hillocks, 25 to 75 feet high, which extends ten miles with an average width of one mile, from sec. 15, Maine, south-south-east by the east side of Turtle lake. The wide moraine resulting from the union of these subordinate series continues south-east to Lake Christina. Where it is crossed by the road from Clitherall to St. Olaf, its first and highest hill is called "Dutch Bluff." At the south side of this, about 125 feet lower, is a pretty lake, half a mile long, bordered all around by morainic hills. This belt of short ridges, knolls, and hollows, has a width of three miles thence to the south-west.

*The Leaf Hills.* In Eagle Lake township, at the north side of Lake Christina, the last described series and that which comes from the south-west by the north side of Pelican lake, are united; and thence for the next 20 miles to the east and north-east the moraine forms a range five to three miles wide, composed of very irregular, roughly outlined hills, 100 to 300 feet high This portion of the moraine is widely known by the name *Leaf mountains*. We also occasionally hear this name applied to its similar but less prominent portions in the west part of this county; and at White Earth agency I was informed that these hills in Becker county are sometimes called a branch of the Leaf mountains. Northeast of East Leaf lake, where the moraine is crossed by the road from Wadena to Otter Tail lake, its eleva-

tions rise only about 100 feet and are named *Leaf hills;* which seems a more appropriate title, and will be used in this report to include the highest part of the range. The common name has currency because they are the only hills in this part of Minnesota which are conspicuously seen at any great distance.

Heights of the Leaf hills and adjoining region are as follows: average elevation of south-eastern Otter Tail county, 1375 to 1400 feet above sea; Wadena, 1358; New York Mills, 1418; Perham, 1375; Alexandria, 1391; Evansville, 1354; Lake Christina, about 1200; St. Olaf, 1344; Turtle lake, 1331; Otter Tail and Rush lakes, about 1325; East and West Leaf lakes, about 1340; East and West Battle lakes, about 1338; Clitherall lake, 1341; Nidaros plain, south-east of last, 1450 to 1460; Dutch bluff, about 1450; Leaf hills in Eagle Lake township, 1400 to 1500; in the north-east corner of Lund and north-west edge of Millerville, Douglas county, 1500 to 1600; in Leaf Mountain township, 1550 to 1650; in the north-west part of Effiington, 1600 to 1700; highest summit of the Leaf hills, thought to be in sec. 32, t. 132, r. 38, about 1750; thence for seven miles north-eastward, 1650 to 1600; depression in range crossed by head of Leaf river, about 1425; hills in next six miles north, to where the series is again crossed by this river below East Leaf lake, 1640 to 1450.

The road from Alexandria to Clitherall crosses this range in the township of Leaf Mountain. The summit of the road is near the south line of this township, about 1525 feet above sea. The top of a hill a quarter of a mile east of this and about 125 feet higher, affords a fine view of these "mountains," which westward and north-eastward rise in most tumultuous confusion 150 to 250 feet or more above the intervening depressions They are massive, though very irregular in contour, with steep slopes. No prevailing trend is noticeable. Between them are enclosed frequent lakes, which vary from a few rods to a mile in length, and one of the largest lies at the north-east foot of our hill. The material is unmodified drift, nearly like that which forms very extensive gently undulating tracts elsewhere. The principal difference is that rock-fragments, large and small, are generally more numerous upon these hills, and occasionally they occur in great abundance.

The Leaf hills are also crossed by the road that runs north-west from Parker's Prairie. In t. 132, r. 38, this road winds three or four miles among their knolls, hills and short ridges, rising about 100 feet above the land on each side. Again, in going from Otter Tail lake to Wadena, this range is encountered one to two miles north-east from East Leaf lake. Here its hillocks are only 40 to 60 feet above the hollows, and 100 to 125 feet above the lake. Their material is gravel and sand with enclosed boulders, unlike the stony and gravelly clay which makes up most of these morainic accumulations. This belt of irregular hillocks and hollows, occupying a width of about two miles, next extends in a course a little west of north 12 miles, running midway between New York Mills and Rush lake, and ends (so far as we are able to report) in hills which rise 100 feet above the general level at the south side of Pine lake.

Outlying hills west of this series occur along the south side of the Leaf lakes, where they are 50 to 75 feet high; and for two miles south from East Battle lake, above which they rise about 150 feet. On the east side of this moraine two lines of hilly and irregular contour have been noted branching

off from it. The most northern starts four miles south from the east end of East Leaf lake, and extends nearly due east through Inman and Oak Valley into the north-west township of Todd county. On the road from Wadena to Parker's Prairie this line is represented by a nearly level tract of unmodified boulder-clay, in contrast with all the rest of this road which has only stratified gravel and sand. Two miles farther east, in sec. 9, t. 133, r. 35, it rises in conspicuous hills fully 100 feet above the general level. The other series starts from the highest part of the Leaf hills, 15 miles south of Leaf lakes, and passes south-east into Douglas county. In its first few miles this range decreases in height from 200 to 75 feet. At the north line of Douglas county it divides into two divergent belts, both showing a rough and broken surface, though the hills of each are only 75 feet or less in height. One of these continues south-east and east through Spruce Hill township, beyond which it has not been traced; the other runs south-south-west to the north-west side of Lake Miltona, along the west side of Lake Ida, by Elk lake and the west part of Lake Lobster, to the conspicuous hills, about 150 feet high, at the south-west corner of Moe. Each of these belts averages about one mile wide. The latter, in its farther extent, seems to lead by a continuous course from the prominent Leaf hills to the almost equally noteworthy development of this moraine through 40 miles' distance in southern Pope and northern Kandiyohi counties.

It may be here remarked that the Leaf Hills are thought by the writer to be a terminal moraine accumulated at the north-west end of a narrow area, which was not covered by ice in this epoch, but was bordered on its north-east and south-west sides by vast lobes of the ice-sheet. This seems to be indicated by the position of angles in the moraine, with branches, which were probably medial, extending from them; as also by associated deposits of stratified drift which cover extensive areas eastward; while it is obvious that such form of the ice-sheet would correspond to that which it had at an earlier period when it reached farther and surrounded a large driftless area in front of this at the south-east. The terminal moraine formed at the ice-margin in our last glacial epoch is therefore thought to be represented by some branch extending east and south-east from the Leaf hills. That region has not yet been explored in reference to its drift formations; but it is believed that a morainic belt will be found traceable continuously to the drift-hills of Manomin, the south-west part of Ramsey county, and West Saint Paul, there crossing the Mississippi river twice and thence bending east to Lake St. Croix, beyond which its course for the next 50 miles is north-eastward as traced by Prof. Chamberlin, in the geological survey of Wisconsin.

The portion of the moraine reaching from northern Becker county to Fergus Falls or perhaps to the south line of Otter Tail county, and also that from the highest part of the Leaf hills to Pine lake, are then probably medial deposits of drift heaped where opposing ice-currents met. The terminal moraine formed at the west side of the area that is supposed not to have been covered by ice at this time, may be represented by the line of irregular low hills which runs by Lake Ida; but it seems more likely that it is found in the rolling tract, nowhere very rough and broken in outlines but rising in smooth swelling hills 50 to 75 or 100 feet high, extending from the higher hills at the south-west corner of Moe north-westward to Pelican lake and Lake Christina.

From the hills in Moe and the north-east part of Solum, lying on the north and west sides of Lake Oscar, the terminal moraine, seldom much elevated above the adjacent country, but distinguished by its irregular hills and hollows, continues with an average width of about one mile, first south-west and south 12 miles to the bridge across Chippewa river in sec. 32, Nora; then south-east, east, and east-north-east 18 miles, passing along the north side of Lake Whipple to Glenwood.

The height of Lake Whipple (also called White Bear lake) is estimated to be about 1100 feet above sea. It is situated near the center of Pope county, and is the largest lake of the county, being seven miles long with an average width of two miles. At its north side, within a half mile or so back from its shore, the very irregular bluffs of this moraine rise 150, and in a few places 200 feet. This ascent forms the margin of a gently undulating plateau which extends indefinitely northward, with an average elevation about the same as the top of these bluffs. At Glenwood the moraine bends southward around the east end of the lake, and thence it appears to be represented by prominent hills along the line between Barsness and Chippewa Falls, joining the well-marked morainic range of southern Pope county at a point 10 miles south of Glenwood. The broken bluffs bordering Lake Whipple at the north and east are thus regarded as the terminal deposits of ice which was pushed north-eastward, covering the place now occupied by this lake; but before the close of this epoch, the ice-front here retreated several miles, after which it halted, perhaps with some reädvance, forming a more conspicuous terminal moraine in Blue Mounds and Barsness, which continues thence finely developed for 40 miles to the east-south-east and east.

The township of Blue Mounds has its name from the hills of this moraine, which begins a mile north-east from the east end of Lake Emily, and extends in a range of very irregular contour, 150 to 200 feet high, or about 1250 to 1300 feet above sea, east along the south side of Signalnas creek, east-south-east through Barsness, by the north side of Woodpecker lake, and between Scandinavia lake and Chippewa Falls, and thence south-east to the south side of Lake Johanna township, where it enters Kandiyohi county. The road from the west end of Lake Whipple to Benson first crosses massively hilly land, 150 feet high, then descends about 100 feet to Signalnas creek, and next climbs about 125 feet among the picturesque ridges and hillocks of the moraine, reaching a point only 30 or 40 feet below its highest summits, which lie within one and a half miles eastward. The range here consists mainly of steep ridges of variable height and length, sometimes a half mile long, running from west to east, with many enclosed irregular hollows. The road from Glenwood to Benson also passes over high swells north of this moraine, whose short, prominent west-to-east ridges it crosses in secs. 20 and 29, Barsness. A beautiful little lake is seen here in a deep hollow of these hills below the road at its west side. Upon reaching the top of the moraine by these roads, one unexpectedly discovers yet higher land within a few miles at the south and south-west, where the north part of Langhei consists wholly of massive swells and hills, 50 to 75 feet above the enclosed depressions and lakelets. This is the highest land in Pope county, being fully 100 feet above the moraine, or 1400 feet above sea. The view from it southward and westward overlooks a gently undulating, but in the distance apparently level tract, 300 to 350 feet lower, extending to the horizon.

The western and southern part of Chippewa Falls gradually becomes more and more hilly as we approach the morainic series at the south and west sides of this township. From Pope Summit, a quarter of a mile north of the village and about 125 feet above the dam, the north-west to south-east range of the terminal moraine is seen rising to about equal height two miles farther south. At the south-west side of Lake Johanna a prominent mass of highland rises 125 feet or so above this lake. Its south-west margin, in sec. 30, descends in rough and broken morainic outlines, forming a part of this series. Here and in its farther course through Kandiyohi county, its highest points are about 1250 or 1300 feet above sea, being 75 to 100 feet above the general level. In the north part of Norway Lake and south-west part of Colfax, it forms a roughly hilly belt two to three miles wide. It is finely seen at the north side of Norway lake and Lake Andrew, where it is called the "Blue hills," or sometimes a "branch of the Rocky Mountains." Its highest knob, called Mount Tom (at south-east corner of sec. 35, Colfax,) commands a fine view. The material of this hill is coarse drift, holding occasional angular boulders up to four feet in diameter and many smaller fragments, mixed also with a large proportion of water-worn gravel. At one point 40 rods north-north-east, boulders up to six feet in diameter are very abundant. The contour here is typically morainic, in short west-to-east ridges of unequal height, very steep, especially on the south side, with correspondingly irregular hollows. Eastward this moraine forms prominent hills in the north-east part of New London and north part of Irving. These cover an area about three miles wide north of Green lake, above which they rise 100 to 150 feet. One of these hills in the south part of sec. 31, Roseville, is called "Sugarloaf Peak." At the south-east corner of Roseville this moraine is called "Cape Bad Luck." The road here climbs 100 feet over a profusion of knolls and hillocks of every form, with no prevailing trend, 25 to 50 feet high above the numerous hollows, which often hold little marshes or lakelets.

This moraine is very prominent from Blue Mounds to Cape Bad Luck, along a south-east and east course of 40 miles. Though it is well known that generally the drift was transported southward, or in some direction between south-east and south-west, it seems necessary to attribute the formation of this range to a glacial current flowing north-east. It appears to mark the north-east boundary of a vast lobe of the ice-sheet, which extended from the Leaf hills to northern Iowa and had its west side at the Coteau. The moraines of its margin were pushed forward by the diverging currents of this ice-lobe, which in approaching its edge were everywhere turned perpendicularly, or nearly so, towards its terminal line. The evidences which usually show in what direction the ice-currents moved, namely, striæ, and the parent ledges from which boulders have been derived, are wanting here, and cannot be appealed to in support of this opinion. No exposures of the underlying rocks have been found in all this region, excepting at one spot seen by Owen on the Red river, a little above Fergus Falls, and commonly along the deeply excavated valley of the Minnesota river, 40 miles south-west. The position of this valley coincides approximately with the axis of this ice-lobe, being so far removed from each of its sides that theoretically it should show no deviation from the axial current. Its striæ, observed at numerous places, all bear nearly south-east. In the absence of

these usual proofs, the reasons for our belief are the continuity of this moraine from the Leaf hills to the Coteau by a great southward loop, of which the range of drift-hills in Pope and Kandiyohi counties forms a part; the wide nearly level area of glacial drift, which is enclosed by this looped hilly belt; the occurrence of a medial moraine on the south side of the terminal in Kandiyohi county; and areas of modified drift north of this terminal moraine, sloping away from it, and thus showing that the waters discharged from the ice-sheet flowed in this direction.

The medial moraine alluded to extends from Mt. Tom four miles south-south-east; it then bends south-westward in sec. 30, New London, and is finely seen for 12 miles, passing along the north-west side of Ringo, Nevada and other lakes, to Ostlund's hill in sec. 22, Mamre. Its contour is typically uneven, being composed of a mixed variety of hillocks and short ridges with many hollows. Throughout most of its course its elevation is only 50 to 75 feet above the general level. Its highest points are the two Dovre hills, about 125 feet above adjoining lakes. The road at the south-west corner of sec. 16, Dovre, runs between these hills, which, though of little height, are yet prominent as compared with the rest of this district, so that they are conspicuously seen for several miles around. They are made of nearly the same kind of drift as Mt. Tom, but have more numerous rock-fragments, both large and small. Wherever a prevailing trend is noticeable, it is parallel, or nearly so, with the course of the series, as has been also noted respecting the terminal moraine at several places

South-eastern Pope county contains several areas of modified drift, within two or three miles north of the terminal moraine, which appear to have been deposited by floods from a melting and retreating ice-sheet. One of these areas of stratified gravel and sand forms an elevated plain a mile across at the south-east side of Lake Johanna. It is bordered on all sides by land 50 to 80 feet lower, and its southern portion is about 90 feet above the lake. It has a descending slope to the north, amounting to ten feet in its mile of extent. Another plateau of similar material, extent, height, and slope of ten feet per mile to the north, occurs on the west side of Lake Johanna; and a little farther north, in sec. 6, Lake Johanna, and sec. 1, Gilchrist, are others somewhat lower, also sloping northward. These plateaus of modified drift have steep sides and nearly or quite flat tops. The intervening tracts are gently undulating lowland, also mostly modified drift, 50 to 75 feet below these high plains. The origin of these deposits seems to have been from glacial melting, which washed away a portion of the drift material that was held in the ice-sheet, and spread it upon these areas while they were still bordered on the east and west by ice-walls. The slope proves that these waters flowed northward. As these beds lie in front of the terminal moraine, it appears that they are of slightly earlier formation, or that they belong to some time in this epoch when the ice-front advanced a few miles beyond its ordinary limits.

Another noteworthy area of modified drift occurs in Roseville, north of Cape Bad Luck. Here the terminal moraine is bordered at its north side for four miles by a flat of gravel and sand, extending from two to three miles wide to Crow River, in which distance it descends about 40 feet. This deposit was probably formed by floods, which were poured down from the ice-sheet at the same time that its terminal moraine was being accumulated.

At lower stages of these waters, as in winter, channels were cut in this plain; one of these, containing a narrow lakelet, occurs close east of the school-house in sec. 22. Similar, but more extensive plains of modified drift are marked features in the topography of Long Island, Martha's Vineyard, Nantucket and Cape Cod, where they lie in front (which is there south) of terminal moraines, sloping away from them and crossed by old water-courses.

The continuation of the moraine beyond Kandiyohi county forms a wider belt of drift-hills, which seldom have the peculiarly rough and broken contour seen farther north-west. It runs through Meeker, Wright, eastern Carver and south-western Hennepin counties. On the opposite side of Minnesota river it bends south, including the north-west corner of Dakota county, the east half of Scott, western Rice and the east edge of Le Sueur county. These hills rise 40 to 100 feet, rarely more, above the intervening depressions, marshes and lakes. They are massive, with moderately steep or gentle slopes, sometimes being nearly a mile long and properly called swells because of their smoothed flowing outlines. It is also to be noted that the boundary of these morainic accumulations becomes somewhat indefinite; there is a gradual change from the slightly undulating areas at each side to rolling land, and then to hills; and these, usually with no prevailing trend, are scattered more or less thickly upon a belt 5 to 15 or even 25 miles wide. This hilly tract extends through the north edge of Meeker county, by the south side of Koronis or Cedar lake, through the north part of Manannah, and eastward includes nearly all of Forest Prairie township, Forest City, except its south-west portion, and Kingston. Farther south, much of this county is specially hilly and must be reckoned as part of this morainic belt. Of this character are Dassel and the wooded eastern portion of Darwin, Collinwood in less degree, Ellsworth in its north and west portions, Greenleaf, the north-east part of Cedar Mills, northern Danielson, south-western Litchfield and most of Acton. Hills also occur one mile north of Litchfield, and five to eight miles north-west in the wooded portion of Harvey. The same hilly land reaches also north-westward, lying at the south side of the typical moraine, and occupying through Kandiyohi and north-eastern Swift counties a width that decreases from 20 to about 5 miles. The Langhei hills, south of Blue Mounds, are the west end of this tract. These too are its only portion that rises into greater prominence than the terminal moraine. Elsewhere these hills are only 40 to 60, or occasionally, as about Swift Falls, 75 to 125 feet high. At their south-west side the land becomes gently undulating or sometimes flat, as in Lake Lillian and Cosmos, forming the margin of the monotonous expanse of nearly level unmodified glacial drift, which reaches thence 75 miles to the hilly Coteau.

In Wright county it is the shorter task to enumerate the districts which are comparatively level. Such are the east portions of South Side and French lake; south-western Corinna; Clearwater prairie, three miles long; Sanborn's or Moody's prairie and adjacent portions of Silver Creek township; and Monticello and West prairies, together six miles long and two to three miles wide. These areas, like the level tract, nine miles wide, which includes the greater part of Darwin and Litchfield in Meeker county, consist of modified drift, or beds of gravel, sand, and clay, gathered from the ice-sheet and deposited by the waters of its melting. In southern Wright county, the vicinity of Waverly, Howard Lake and Smith Lake, and most of

the townships south of the railroad, excepting Franklin in which Delano is situated, consist of nearly level or gently undulating areas of unmodified drift. The swells and hills of this county are mostly 40 to 75 feet high. In its south-east portion they rise 100 to 125 feet above Crow river. Among these hills are numerous lakes, which lie in gently sloping hollows, seldom having steep shores. The most rough and typically morainic area observed is in the south-east part of Silver Creek township, where from Silver lake to Lake Ida the contour is a multidude of small hillocks and ridges of unmodified drift, 30 to 50 feet above the hollows, with no parallelism or prevailing trend. Thence a somewhat similar formation continues five miles north to the river-road. Especially prominent hills, two miles south of Clearwater, and two miles south-east of Monticello, also deserve mention. These hills in Meeker and Wright counties vary in height, descending eastward with the general slope of the country, from 1225 to 1000 feet above sea.

Hennepin county is crossed by this belt of hills in its west and south-west portions, and they are finely exhibited about Minnetonka lake.(922 feet in altitude,) above which they rise 50 to 100 feet. In Carver county the townships of Chanhassen and Laketown, the north-west part of Chaska, and northern Dahlgren, are a portion of the same belt of massive hills, with no uniformity of trends, elevated 40 to 75 feet above the hollows. A rolling surface, with swells half as high as the foregoing, continues west to Young America. The remainder of Carver county, excepting its border along the Minnesota river, is gently undulating or nearly level. All these areas are unmodified drift.

In Eden Prairie and Bloomington the moraine extends along the north side of Minnesota river, to within about eight miles south-west of Fort Snelling. The river-bluff here is 140 feet high, and at a mile or two northward these morainic hills rise 100 feet higher, their tops being 950 feet approximately above sea. South-east of the Minnesota river drift-hills, some of which attain equal or greater height, occupy Burnsville, excepting the river valley, and the west part of Lakeville, in the north-west edge of Dakota county. They also cover eastern Scott county to a meridian line drawn through Shakopee. Here these swells and hills generally rise 30 to 60 feet above the hollows, and in some districts 75 to 100 feet. They are most numerous and prominent along a south-south-west course from Burnsville to the south part of Cedar Lake township. Farther west in Scott county, the contour is moderately undulating in swells 10 to 30 feet high.

The western part of Rice county, notably its west range of townships, consists mainly of these terminal drift-deposits, often roughly hilly. In Le Sueur county they give a rolling contour to the east side of Lanesburg, to Montgomery and Kilkenny, and in less degree to Lexington, Cordova, and Elysian; while in Waterville, at the south-east corner of this county, they form hills 50 to 125 feet high south of lakes Tetonka and Sakata. This was the south-eastern limit of my exploration. The continuance of this moraine to the Coteau de Missouri has been already stated. As part of the field-work of next year, we hope to make a thorough examination of that region; and also of that lying eastward from the Leaf hills and thence south to the hills of Manomin, in which distance there seem to be reasons for believing that another terminal moraine, contemporaneous and continuous with the Leaf hills, will be found, marking the south-west limit of a lobe of the ice-

sheet that pushed outward from Lake Superior and its bordering high lands. A map of this formation will be presented in our final report.

*River Systems.* The drainage of the portion of Minnesota here described is not much influenced by the presence of this moraine. Its accumulations rise to great prominence only in the Leaf hills. Generally they are not more than 100 feet high, and are separated by frequent hollows, which allow a free passage to streams. In comparison with the wider areas of gently undulating land, this hilly belt is narrow; and its highest elevations are small in comparison with the greater changes of altitude which come in gradually and almost imperceptibly in traveling 100 or 200 miles, such as that which makes Douglas, Otter Tail, and Becker counties 500 to 700 feet above Minneapolis and Saint Paul. The course of the moraine coincides nearly with the watershed dividing the basin of the upper Mississippi from that of the Minnesota river; but this height of land and consequent division of drainage are probably due to the height of the underlying rocks rather than to the thickness of drift there.

The principal tributaries to the Mississippi river, flowing partly or mainly from this area, are the Crow Wing river, whose branches, Shell, Leaf, and Long Prairie rivers, drain the east portion of Becker, Otter Tail, and Douglas counties; the Sauk river, which has its headwaters in Osakis lake, and in the north-east corner of Pope county; the Clearwater river, draining north eastern Meeker and north-western Wright counties; and the Crow river, which has its waters from the east edge of Pope, eastern Kandiyohi, north-eastern Renville, Meeker, Wright, McLeod, and northwestern Carver counties. The farthest source of the Crow river, in Grove Lake, Pope county, is 90 miles from its mouth, in a direct line.

Winnipeg lake and Hudson bay receive the drainage from the north-west part of our area, by the Red River of the North, which this report, following the example of Owen, calls by this name from the mouth of Otter Tail lake. This is 42 miles east of its junction with the Bois des Sioux river at Breckenridge, where the Red river turns its course ninety degrees, thence flowing north. The Bois des Sioux, a much smaller stream, having its source in Lake Traverse, is the continuation of the nearly straight course of the Red river below this junction. The name Otter Tail river is restricted to the stream which flows to the south 50 miles from the north side of Becker county, passing through Elbow, Many Point, Height of Land, Pine, and Rush lakes, besides others of less size, and emptying into Otter Tail lake. The principal tributaries of the Red river from this area are the Wild Rice river, one of whose sources is White Earth lake, while its south branch drains north-western Becker and north-eastern Clay counties; the Buffalo river, which drains the rest of Clay county, and has its farthest sources near the center of Becker and in north-eastern Wilkin county, and the Pelican river, which joins the Red river from the north 22 miles east of Breckenridge. The last, 45 miles long in straight line, receives the waters of many lakes, of which the largest are Detroit, Cormorant, Pelican, Lizzie, and Lida. At Fergus Falls the Red river has a descent of about 85 feet, affording very valuable water-power. The Rabbit river is a small tributary to the Bois des Sioux in southern Wilkin county; and the Mustinka river, draining western Grant, north-western Stevens, and most of Traverse county, enters Traverse lake eight miles from its outlet.

The Minnesota river receives only two large tributaries from its north side, namely, the Pomme de Terre and Chippewa rivers. The farthest sources of the former are lakes in Tordenskjold and Dane Prairie, Otter Tail county. Its course is south 75 miles, joining the Minnesota river 20 miles below Big Stone Lake. The Chippewa river, nearly parallel with this and lying 5 to 15 miles farther east, drains western Douglas, nearly all of Pope, the eastern two-thirds of Swift, and the west half of Chippewa county. The other branches of the Minnesota river within this area are small, none of them exceeding 30 miles in length, as Hawk creek, 21 miles below the Chippewa; Beaver creek, again 21 miles south-east from the last; Rush river, in southern Sibley county; Carver creek, at Carver; and, on the opposite side of the Minnesota, Le Sueur and Sand creeks, and Credit river, in Le Sueur and Scott counties.

The watersheds are mostly portions of wide gently undulating areas, interspersed with frequent lakes and sloughs, and have nothing except their slightly greater elevations to distinguish them from the basins which they divide. The erosion of the drift-sheet by drainage has been small in the north and north-east portions of this region, where the valleys, as of Pelican river, the upper part of the Red river, and the Crow river, are not generally bordered by bluffs between which the streams have excavated a passage, or by bottom-lands that have become filled with their sediment. Instead they meander among the hills and swells of the drift, often flowing through lakes, and only having occasional bluffs and alluvial lands along the lower part of their course.

*Lake Agassiz.* The lacustrine basin of the Red River valley, and the deeply excavated channel which holds Traverse and Big Stone lakes and the Minnesota river, present quite different and more interesting features, produced by the obstruction of drainage in its present course, while the ice-sheet, subdued by a more temperate climate, was yielding its ground between north-western Minnesota and Hudson bay. During this retreat of the ice, great quantities of water were supplied by its melting, loaded, as the modified drift shows, with a large amount of gravel, sand and clay. Wherever there was free drainage away from the ice-front, these materials were deposited in the valleys along which these floods descended toward the ocean The high water of the rivers, like that which now occurs for a few days in the freshets of spring, was thus maintained through the entire summer; and this was repeated yearly till the glacial sheet had retreated beyond their lines of watershed. The abundant supply of sediment through this time gradually lifted these floods upon the surface of thick and wide plains, sloping with the valleys. After the departure of the ice, the supply of both water and sediment was so diminished that the streams could no longer overspread these flood-plains and add to their depth, but were henceforth occupied mainly in slow excavation and removal of these deposits, leaving remnants of them as plains or terraces, often 100 to 200 feet, or more, above their present channel. The Loess bluffs bordering the Missouri river are of this origin. We have now to consider an area where such free drainage could not take place, because the descent of the land is northward, in the same direction with the retreat of the ice-sheet. As soon as this receded beyond the watershed dividing the basin of the Minnesota from that of the Red river, it is evident that a lake, fed by the glacial melting, stood at the

foot of the ice-fields, and extended northward as they withdrew along the valley of the Red river to Lake Winnipeg, filling this valley and its branches to the height of the lowest point over which an outlet could be found. Until the ice-barrier was melted upon the area now crossed by the Nelson river, thereby draining this glacial lake, its outlet was along the present course of the Minnesota river. At first its overflow was upon the nearly level undulating surface of the drift, 1100 to 1125 feet above sea, at the west side of Traverse and Big Stone counties; but in process of time this cut a channel here 100 to 150 feet deep, the highest point of which is almost exactly 1000 feet above sea.* From this outlet the Red River valley, 30 to 50 miles wide, stretches 315 miles north to Lake Winnipeg, which is 710 feet above sea. Along this entire distance there is a very uniform continuous descent of a little less than one foot per mile. The drift contained in the ice-sheet upon this area, and the silt gathered by glacial rivers from each side, were here deposited in a lake, shallow near its mouth, but becoming gradually deeper northward. At the north line of the United States, its depth was 200 feet, and at Lake Winnipeg 300 feet. Beyond our national boundary, this lake covered a larger area, varying from 100 to 200 miles in breadth at and west of Lake Winnipeg; and its total length appears to have been at least 600 miles. Because of its relation to the retreating continental ice-sheet, it is proposed to call this *Lake Agassiz*, in memory of the first prominent advocate of the theory that the drift was produced by land-ice.

The basin of Lake Agassiz, now drained in its southern portion by the Red river, has an exceedingly flat surface, sloping imperceptibly northward, as also from each side to its central line. The Red river has its course in this axial depression, where it has cut a channel 20 to 60 feet deep. It is bordered by only few and narrow areas of bottom-land, instead of which its banks usually rise steeply on one side and by moderate slopes on the other, to the lacustrine plain which thence reaches nearly level 10 to 25 miles from the river. Its tributaries cross the plain in similar channels, which, as also the Red river, have occasional gullies connected with them, dry through most of the year, varying from a few hundred feet to a mile or more in length. Between the drainage lines, areas often 5 to 15 miles wide remain unmarked by any water-courses. The highest portions of these tracts are commonly from 2 to 5 feet above the lowest. The material of the greater part of this ancient lake-bed is fine clayey silt, horizontally stratified; but at its south end, in Traverse county and the south half of Wilkin county, it is mostly unstratified boulder-clay, which differs from the rolling or undulating unmodified drift of the adjoining region only in having its surface nearly flat. Both these formations are almost impervious to water, which therefore in the rainy season fills their shallow depressions, but none of these are so deep as to form permanent lakes. Even sloughs which continue marshy through the summer are infrequent, but, where they do occur cover large areas, usually several miles in extent. In crossing the vast plain of this valley on clear days, the higher land at its sides, and the groves along

* The height of Lake Traverse, according to leveling by United States engineers, in connection with Gen. Warren's survey of the Minnesota river, is 1000 feet. This is 8 feet above Big Stone lake, from which it is separated at the lowest place by only a slight watershed, perhaps five feet above Lake Traverse. Lake Winnipeg, by the survey of the Canadian Pacific railway, is 710 feet above sea.

its rivers are first seen in the distance as if their upper edges were raised a little above the horizon, with a very narrow strip of sky below. The first appearance of the tree-tops thus somewhat resembles that of dense flocks of birds flying very low several miles away. By rising a few feet, as from the ground to a wagon, or by nearer approach, the outlines become clearly defined as a grove, with a mere line of sky beneath it. Besides this mirage, the traveller is also reminded, in the same manner as at sea, that the earth is round. The surface of the plain is seen only for a distance of three or four miles; houses and grain-stacks have their tops visible first, after which, in approaching, they gradually come into full view; and the highlands, 10 or 15 miles away, forming the side of the valley, apparently lie beyond a wide depression, like a distant high coast.

In Clay county the east side of Lake Agassiz coincided nearly with the line between ranges 45 and 46. From the north line of the county to the Northern Pacific railroad, the land rises about 300 feet in going a few miles eastward, and thence stretches away 25 miles, everywhere slightly undulating, but with little change in its general height. In southern Clay county and at the east side of Wilkin county, the east shore of this glacial lake ran a few degrees east of south, to where it crosses the line of Otter Tail county, 10 miles west of Fergus Falls. Beyond this it has a south-east course about six miles to the Red river. At its east side along this distance, the glacial drift is rolling and hilly, as already described in connection with the moraine, which in south-western Otter Tail county is only 8 to 10 miles east of this basin. From the Red river the lake shore ran southward through Western township; thence in Grant county it appears to curve to the south-east, south and south-west. It crosses the railroad about a mile north-west of Herman, and its further course is by a curve south-west, west, and north-west, passing through the south-east part of Traverse county, and coming to Lake Traverse at its bluffs on the south side of the Mustinka river. Red and Bois des Sioux rivers lie 15 to 20 miles west of this shore-line.

*Beaches and deltas*, as well as the change from a smoothed to an undulating surface, mark the border of this lacustrine area. At and west of Muskoda, the Northern Pacific railroad cuts through a thick and extensive deposit of sand, with beds of gravel and clay in some portions, constituting a plain one and a half miles wide. This extends two or three miles to the north, and is also represented by similar accumulations south of the Buffalo river, which here enters the area formerly covered by Lake Agassiz. These beds have their surface 1075 to 1100 feet above sea, being 100 feet below the adjoining uplands on the east, and 150 feet above the lacustrine plain, which begins two miles farther west and extends 15 miles to the Red river. They appear to be the delta brought down by the Buffalo river and spread in the side of the lake at its mouth. Since the drainage of the lake the river has excavated a large gap through this deposit. A sixth of a mile east of Muskoda station, at the east edge of the delta-plain, is a ridge of interbedded gravel and sand, 25 rods wide and 10 feet high, with its top about 1110 feet above sea. A fine section is exposed by its excavation for railroad ballast, showing the stratification to be mainly level, but inclined at the sides parallel with the gently sloping surface. This beach ridge or bar extends about a half mile from north to south. It is separated from the higher land eastward by a depression about 10 feet deep and a quarter of a mile wide. Mar-

ginal deposits of considerable extent, like the plain of Muskoda, are only found where some stream entered the lake; but beach ridges, similar to the foregoing, were noted at several places in crossing the shore-line of this lake, and, when attention is given to tracing them, will probably be found continuous through long distances. Such a ridge crosses the north line of Wilkin county near the north-west corner of sec. 4, t. 136, r. 45, extending at least one and a half miles from north to south. It was again crossed near the south-east corner of sec. 21, Western, where the road from Fergus Falls to Campbell turns from a south-west to a more nearly west course. Here the ascent from its east side is 10 feet, and the descent at the west about 20. The width of the ridge, including its slopes, is 20 or 25 rods. About a mile farther west the road crosses a second ridge of half this size, about 20 feet below the first. One and a half miles north-west from Herman is a beach-ridge 15 feet above the lacustrine plain at its north-west side. The depression south-east of it is 6 or 7 feet deep and 30 rods wide, and from this there is an ascent of about 15 feet to the plain of Herman, which was therefore above the level of the lake when this beach was formed. Three miles farther north-west (at the 183rd mile-post of the railroad) is a smaller beach-ridge. The top of this is about 1035, and of that near Herman about 1055 feet above sea. All these beaches consist of sand and water-worn gravel; and in Western and Herman it is noteworthy that all the adjoining areas are boulder clay. It is expected that a full exploration of these shore-lines will be made before the completion of this survey, so that the final report shall contain a map of this lake, so far as it lay within the limits of Minnesota.

*The Outlet of Lake Agassiz.* The excavation of the remarkable valley occupied by the Minnesota river was first explained in 1868 by Gen. G. K. Warren, who attributed it to the outflow from this ancient lake that filled the basin of Red river and Lake Winnipeg. This valley or channel begins at the northern part of Lake Traverse, and first extends south-west to the head of this lake, thence south-east to Mankato, and next north and north-east to the Mississippi at Fort Snelling, its length being about 250 miles. Its width varies from one to four miles, and its depth is from 100 to 225 feet. The country through which it lies, as far as to Carver, about 25 miles above its junction with the Mississippi, is a nearly level expanse of till, only moderately undulating, with no prominent hills or notable depressions, excepting this deep channel and those formed by its tributary streams. Below Carver it intersects the hilly morainic belt which has been already described. Its entire course is through a region of unmodified drift, which has no exposures of solid rock at its surface within long distances upon each side. Probably no other channel of equal extent and depth has been eroded in till upon either this or the old continent.

Bluffs in slopes from 20° to 40°, and rising 100 to 200 feet to the general level of the country, form the sides of this trough-like valley. They have been produced by the washing away of their base, leaving the upper portion to fall down and thus take its steep slopes. The river in deepening its channel has been constantly changing its course, so that its current has been turned alternately against the opposite sides of its valley, at some time undermining every portion of them. In a few places this process is still going forward, but mainly the course of the Minnesota river is in the bottom-land, which descends in gentle or often broken slopes 10 to 40 or 50 feet

within one fourth to one half mile from the foot of the bluffs; then becoming the present flood-plain, one eighth to one half mile, or rarely one mile or more. in width, with its height 5 or 10 feet above ordinary low water. Comparatively little excavation has been done by the present river. As we approach its source, it dwindles to a small stream, flowing through long lakes, and we finally pass to Lake Traverse, which empties northward; yet along the upper Minnesota and at the divide between this and Red river, this valley or channel and its enclosing bluffs are as remarkable as along the lower part of Minnesota river. It is thus clearly shown to have been the outlet of Lake Agassiz, excavated while the melting ice-sheet supplied extraordinary floods, much greater in volume than the combined waters of the Minnesota and Nelson rivers at the present time.

This valley in many places cuts through the sheet of drift, and reaches the underlying rocks, which have frequent exposures along its entire course below Big Stone lake. Their contour is much more uneven than that of the drift. In the 100 miles from Big Stone lake to Fort Ridgely the strata are metamorphic gneisses and granites, which often fill the entire valley, one to two miles wide, rising in a profusion of knolls and hills, 50 to 100 feet above the river. The depth eroded has been limited here by the presence of these rocks, among which the river flows in a winding course, crossing them at many places in rapids or falls. From New Ulm to its mouth the river is at many places bordered by Cretaceous and Lower Silurian rocks, which are nearly level in stratification. These vary in height from a few feet to 50 or rarely 75 or 100 feet above the river. From Mankato to Ottawa the river occupies a valley cut in Shakopee limestone underlain by Jordan sandstone, which form frequent bluffs upon both sides, 50 to 75 feet high. After excavating the overlying 125 to 150 feet of till, the river here found a former valley, eroded by pre-glacial streams. Its bordering walls of rock, varying from one fourth mile to at least two miles apart, are in many portions of this distance concealed by drift, which alone forms one or both sides of the valley. The next point at which the river is seen to be enclosed by rock-walls, is in its last two miles, where it flows between bluffs of Trenton limestone underlain by St. Peter sandstone, 100 feet high, and about a mile apart. This also is a pre-glacial channel, its farther continuation being occupied by the Mississippi river. The only erosion effected by the Minnesota river here since the glacial period has been to clear away a part of the drift with which the valley was then filled. Its depth at some earlier time was much greater than now, as shown by the salt-well on the bottom-land of the Minnesota river at Belle Plaine, where 202 feet of stratified gravel, sand and clay were penetratad before reaching the rock. The bottom of the pre-glacial channel there is thus at least 175 feet lower than the mouth of the Minnesota river. The excavation of the drift down to the old rocks by the outflow from Lake Agassiz, enables us to estimate approximately the depth of the general drift-sheet upon this part of Minnesota. It probably averages about 150 feet.

Heights of the bluffs, which form the sides of this valley, composed of till enclosing layers of gravel and sand in some places, and frequently having rock at their base, are as follows, stated in feet above the lakes and river: along the south part of Lake Traverse, 100 to 125; at Brown's Valley and along Big Stone lake, mainly about 125, the highest portions reaching 150;

at Ortonville, 130; at Lac qui Parle and Montevideo, 100; at Granite Falls, 150; at Minnesota Falls, 165; thence to Redwood Falls, Fort Ridgely and New Ulm, 165 to 180; at Mankato 200 to 225; at St. Peter and Ottawa, 220 to 230; at LeSueur and Henderson, 210 to 225; at Belle Plaine and Jordan, about 230; and at Shakopee 210 to 220. The morainic hills through which this valley extends below Shakopee are 225 to 250 feet in height. The elevation of Minnesota river above the sea is given on a following page. The expanse of till through which this channel is eroded slopes from 1125 feet above sea at Big Stone lake to 975 at Mankato, in 140 miles; and thence it descends to 925 at Shakopee, in 50 miles. This channel, as far as to Mankato, lies nearly midway between the terminal moraine previously described and the Coteau des Prairies, toward each of which there is a very slight ascent, sufficient to cause drainage to follow this central line.

Lakes Traverse and Big Stone are from one to one and a half miles wide, mainly occupying the entire area between the bases of the bluffs. Lake Traverse is 23 miles long; it is mostly less than 10 feet deep, and its greatest depth probably does not reach 20 feet. Big Stone lake is 26 miles long, and its greatest depth is reported to be from 15 to 30 feet. The portion of the channel between these lakes is widely known as Brown's Valley. As we stand upon the bluffs here, looking down 125 feet on these long and narrow lakes in their trough-like valley, which extends across the five miles between them, where the basins of Hudson bay and the Gulf of Mexico are now divided, we have nearly the picture which was presented when the melting ice-sheet of British America was pouring its floods along this hollow. Then the entire extent of the valley was doubtless filled every summer by a river which covered all the present areas of flood-plain, in many places occupying as great width as these lakes.

Gen. Warren observes that Lake Traverse is probably due to a partial silting up of the channel since the outflow from the Red River basin ceased, the Minnesota river at the south having brought in sufficient alluvium to form a dam; while Big Stone lake is similarly referred to the sediment brought into the valley just below it by Whetstone river. The deep, winding channel of the Whetstone river near its mouth is quite remarkable; and its level alluvium, about 5 feet above the lake, fills the valley, a mile wide between Big Stone City and Ortonville.

Fifteen miles below Big Stone lake, the Minnesota river flows through a marshy lake four miles long and about a mile wide. This may be due to the accumulation of alluvium brought into the valley by the Pomme de Terre river, which has its mouth about two miles below. Twenty-five miles from Big Stone lake, the river enters Lac qui Parle, which extends 8 miles, with a width varying from one-half to three-fourths of a mile and a maximum depth of 12 feet. This lake, as Gen. Warren suggests, has been formed by a barrier of stratified sand and silt which the Lac qui Parle river has thrown across the valley. He also shows that Lake Pepin on the Mississippi is dammed in the same way by the sediment of the Chippewa river; and that Lake St. Croix and the last 30 miles of the Minnesota river are similarly held as level back-water by the recent deposits of the Mississippi.

All the tributaries of the Minnesota river have cut deeply into the drift, because the main valley has given them the requisite slope. The largest of these extend many miles, and have their mouths level with the bottom-land

of the Minnesota river. The bluffs of all these valleys are also everywhere seamed and gullied by frequent rills and springs, many of which flow only after rains. Few of the large inlets have any great amount of sediment deposited opposite their mouths, showing that their excavation was mostly done at the same time with that of the main valley. The short ravines are more recent in their origin, and the material that filled their place is commonly spread in fan-shaped, moderately sloping banks below their mouths, which are thus kept at a height from 30 to 40 feet above the present flood-plain. The road from Fort Ridgely to New Ulm runs along the side of the bluff at the only height where a nearly level straight course could be obtained, being just above these deposits and below the ravines.

The valleys of the Pomme de Terre and Chippewa rivers, 75 to 100 feet deep along most of their course, and one-fourth mile to one mile in width, were probably avenues of drainage from the melting ice-fields in their northward retreat. Between these rivers, in the 22 miles from Appleton to Montevideo, the glacial floods at first flowed in several channels, which are excavated 40 to 80 feet below the general level of the drift-sheet, and vary from one-eighth to one-half mile in width. One of these, starting from the bend of the Pomme de Terre river, 1½ miles east of Appleton, extends 15 miles south-east to the Chippewa river near the center of Tunsburg. This old channel is joined at Milan station by another, which branches off from the Minnesota valley, running four miles east-south-east; it is also joined at the north-west corner of Tunsburg by a very notable channel which extends eastward from the middle of Lac qui Parle. The latter channel, and its continuation in the old Pomme de Terre valley to the Chippewa river, are excavated nearly as deep as the channel occupied by the Minnesota river. Its west portion holds a marsh generally known as the "Big Slough." Lac qui Parle would have to be raised only a few feet to turn it through this deserted valley. The only other localities where we have proof that the outflow from Lake Agassiz had more than one channel are 7 and 10 miles below Big Stone lake, where isolated remnants of the general sheet of till occur south of Odessa station and again three miles south-east. Each of these former islands is about a mile long, and rises 75 feet above the surrounding low land, or nearly as high as the bluffs enclosing the valley, which here measures four miles across, having a greater width than at any other point.

## ELEVATIONS.

In connection with the foregoing description of topographic features, it seems desirable to present the series of altitudes which have been determined in this region by railroad and other surveys. They are mostly copied from Prof. Winchell's first annual report as geologist of Minnesota, in which they were referred to Lake Superior as a datum, calling it 600 feet above sea. Since that publication, the researches of Messrs. Gardner and Gannett, of the U. S. Geological Survey of the Territories, have shown the height of Lake Superior to be 609.4 feet above mean tide. The correction which this requires is adopted in the following tables; and in those gathered from later reports a few other changes are made, as called for by determinations of other datum points, mainly following Gannett's *Lists of Elevations*, fourth edition. These heights are stated in feet above mean sea-level:

*Northern Pacific Railroad.*

| | | | |
|---|---|---|---|
| Lake Superior, | 609.4 | Audubon, | 1317 |
| Brainerd, | 1214 | Lake Park, | 1342 |
| Mississippi river (bed), | 1147 | Hawley, | 1159 |
| Wadena, | 1358 | Muskoda, | 1092 |
| Leaf river (bed), | 1316 | Buffalo river (bed), | 947 |
| New York Mills, | 1418 | Glyndon, | 932 |
| Otter Tail river (bed), | 1327 | Moorhead, | 913 |
| Perham, | 1375 | Red river, low water, | 851 |
| Hobart, | 1393 | Red river, high water | 885 |
| Pelican river (bed) | 1346 | Fargo, | 912 |
| Detroit, | 1371 | Jamestown, | 1415 |
| Oak Lake station, | 1376 | Missouri river, at Bismarck, | 1649 |

*St. Paul, Minneapolis & Manitoba Railroad.*

*a. From St. Cloud to St. Vincent.*

| | | | |
|---|---|---|---|
| East Saint Cloud, | 1020 | Red river, at Dayton bridge, | 1071 |
| Mississippi river, low water, | 962 | Creek-bed near Barnesville, | 997 |
| West Saint Cloud, | 1034 | Track on bridge here, | 1012 |
| Osakis, | 1337 | Glyndon, | 932 |
| Victoria, | 1375 | Buffalo river, track, | 928 |
| Alexandria, | 1391 | Buffalo river, water, | 915 |
| Ida, | 1411 | Averill, | 927 |
| Chippewa river, track, | 1369 | Felton, | 925 |
| Chippewa river, water, | 1339 | Borup, | 921 |
| Evansville, | 1354 | Wild Rice river, track, | 919 |
| Summit, 1 m. beyond last, | 1378 | Wild Rice river, water, | 910 |
| Christina, | 1228 | Red Lake river, track, | 857 |
| St. Olaf, | 1344 | Red Lake river, water, | 850 |
| Summit, 2½ m. beyond last, | 1366 | Saint Vincent, | 801 |
| Pomme de Terre river, track, | 1239 | Red river, low water, | 767 |
| Pomme de Terre river, water, | 1205 | Red river, high water, | 796 |

*b.—From St. Paul to Breckenridge.*

| | | | |
|---|---|---|---|
| Saint Paul, | 698.4 | Benson, | 1042 |
| Minneapolis, | 830 | Chippewa river, track, | 1030 |
| Lake Minnetonka, water, | 922 | Chippewa river, water, | 1021 |
| Delano, | 923 | Clontarf, | 1041 |
| Waverly, | 1007 | Hancock, | 1150 |
| Twelve Mile Creek, | 995 | Summit, 1½ miles beyond last, | 1167 |
| Howard Lake sta., | 1049 | Pomme de Terre river, track, | 1073 |
| Smith Lake sta., | 1049 | Pomme de Terre river, water, | 1062 |
| Cokato, | 1022 | Morris, | 1122 |
| Darwin, | 1127 | Summit, 2 miles beyond last, | 1151 |
| Litchfield, | 1125 | Donnelly, | 1121 |
| Swede Grove, | 1186 | Herman, | 1063 |
| Atwater, | 1207 | Mustinka creek, | 1021 |
| Summit, 4½ miles beyond last, | 1264 | Gorton, | 1017 |
| Kandiyohi, | 1216 | Tintah, | 991 |
| Willmar, | 1124 | Campbell, | 977 |
| St. John's, | 1116 | Doran, | 968 |
| Kirkhoven, | 1104 | Breckenridge, | 957 |
| De Graff, | 1056 | | |

### *Hastings & Dakota Railroad.*

(Corrected at and west of Shakopee to agree with the height of Minnesota river at tha place.)

| | | | |
|---|---|---|---|
| Hastings, | 709.4 | Chaska, | 740 |
| Farmington, | 900.6 | Carver, | 827 |
| Prior Lake sta., | 954 | Dahlgren, | 994 |
| Prior Lake, water, | 914 | Benton, | 959 |
| Shakopee, | 768 | Young America, | 1002 |
| Minnesota river, low water, | 704.5 | Tiger lake, water, | 991 |
| Minnesota river, high water, | 731 | Glencoe, | 1015 |

### *Winona & St. Peter Railroad.*

| | | | |
|---|---|---|---|
| Winona, | 652.65 | Oshawa, | 980 |
| Lewiston, | 1211 | Nicollet, | 978 |
| Rochester, | 990 | Minnesota river, high water, | 808 |
| Owatonna, | 1047 | New Ulm, | 835 |
| Mankato, | 779 | Sleepy Eye, | 1032 |
| Kasota, | 837 | Marshall, | 1173 |
| St. Peter, | 810 | State line, | 1475 |
| Minnesota river, high water, | 754 | Summit of Coteau, 22 ms. W., | 1999 |

### *St. Paul & Sioux City Railroad.*

The profile of this line, stated on p. 38 of Gannett's *Lists of Elevations*, and derived from the first annual report on the Geology of Minnesota, is 50 feet, approximately, too high, as compared with the determination of Minnesota river by the U. S. Engineer Corps.

### *Survey for Minnesota Northern Railroad.*

| | | | |
|---|---|---|---|
| Wadena, | 1358 | Bass lake, | 1333 |
| Pease Prairie, t. 133, r. 38, | 1459 | Red river at Fergus Falls, | 1181 |
| Clitherall lake, | 1341 | Top of dam at Pelican Rapids, | 1311 |
| Turtle lake, | 1331 | | |

### *Survey for Hutchinson Branch of the Minneapolis & Northwestern Railway.*

| | | | |
|---|---|---|---|
| Top of Watertown dam, | 925 | Swan lake, | 1045 |
| Ocean marsh, 7 ms. W., | 997 | Crow river, low water, | 1029 |
| Winsted lake, | 994 | Hutchinson, | 1042 |

### *Mississippi River.*

| | | | |
|---|---|---|---|
| Lake Itasca, | 1575 | Lake City, low water, | 664.2 |
| Mouth of Leech Lake river, | 1356 | Winona, low water, | 639.9 |
| Mouth of Sandy Lake river, | 1253 | La Crosse, low water, | 626.3 |
| Mouth of Crow Wing river, | 1130 | Dubuque, low water, | 599.1 |
| At head of Sauk Rapids, | 991 | Keokuk, low water of 1851, | 481.8 |
| Saint Cloud, low water, | 962 | Keokuk, high water of 1851, | 502 5 |
| Top of Saint Anthony's falls, low water, | 800 | Saint Louis, low water, | 394.5 |
| | | Saint Louis, high water of 1844 | 435.9 |
| One-half mile below Saint Anthony's falls, low water, | 721 | Cairo, ordinary low water, | 291.2 |
| | | Cairo, low water of 1871, | 279.3 |
| Mouth of Minnesota river, low water, | 704.4 | Cairo, high water of 1867, | 333 |
| | | Memphis, low water, | 184 |
| Saint Paul, low water, | 685.4 | Memphis, high water, | 219 |
| Saint Paul, high water, | 706.4 | Natchez, low water, | 66 |
| Hastings, low water, | 670.5 | Baton Rouge, low water, | 34 |

*Minnesota River, low-water slope.*

(Levels by U. S. Engineer Corps.)

| | | | |
|---|---|---|---|
| Big Stone lake, | 992.80 | Mankato, | 765.7 |
| Pomme de Terre river, | 962.68 | Saint Peter, | 743.4 |
| Lac qui Parle, | 954.04 | Ottawa, | 736 |
| Chippewa river, | 939.84 | LeSueur, | 729.2 |
| Foot of Minnesota Falls | 883.14 | East Henderson, | 724.8 |
| Yellow Medicine river, | 875.12 | Henderson, | 723.4 |
| Redwood river, | 831.67 | Faxon, | 713.4 |
| Fort Ridgely, | 807.39 | Belle Plaine, | 709.8 |
| Big Cottonwood river, | 795.92 | Crest of Little Rapids, | 706 |
| Judson, | 773.78 | Foot of Little Rapids, | 704.8 |
| South Bend, | 769.2 | Mouth, | 704.4 |
| Blue Earth river, | 768.9 | | |

*Red River of the North.*

| | | | |
|---|---|---|---|
| Lake Traverse, | 1000.5 | Moorhead, low water, | 851 |
| Otter Tail lake, | 1325 | Moorhead, high water, | 885 |
| Fergus Falls, | 1181 | Saint Vincent, low water, | 767 |
| Dayton bridge, | 1071 | Saint Vincent, high water, | 796 |
| Breckenridge, | 940 | Lake Winnipeg, | 710 |

*The Great Lakes.*

| | | | |
|---|---|---|---|
| Superior, | 609.40 | Erie, | 573.08 |
| Michigan and Huron, | 589.15 | Ontario, | 250 |

FOREST AND PRAIRIE.

A considerable part of the area included under this report is well timbered. These forests at their borders and around the few prairies which they enclose, become gradually more open with fewer and smaller trees, or form scattered groves, with intervening bushes or grass-land. The wooded part of this district is its north-east and east side, and takes in nearly all of Becker and Otter Tail counties, in which its west boundary extends from the White Earth Agency south to the Northern Pacific railroad; thence west by Audubon, and then south by Cormorant, Pelican, Lizzie and Prairie lakes; in Erhard's Grove and Elizabeth, it includes a few miles on the west side of Pelican river; and next bends south eastward, passing by the north side of Fergus Falls, to Wall lake and the north edge of St. Olaf. Through the center of Otter Tail county the woods of its east and west portions are divided by a nearly continuous belt destitute of forest, averaging about six miles wide, which reaches from Lake Christina to Clitherall, Otter Tail and Rush lakes, and onward by Perham to the North line of the county. About half of Douglas county is forest, very irregularly bounded, its south-west limit being in the vicinity of Lakes Oscar and Mary. Pope county has only scattered groves, sometimes one or two miles wide, but separated from each other by yet wider areas of prairie, which include probably nineteen-twentieths of the county. Kandiyohi county has an area of forest 15 miles long from west to east and 3 to 10 miles wide, lying north-west, north and north-east of Green lake; also, groves of small extent, found frequently on the borders of lakes in all parts of the county except its south-west quarter.

*The Big Woods.* In Meeker county and others at the east and south-east, a belt of timber about 45 miles wide extends nearly one hundred miles from

north to south, commonly called the "Big Woods." Like the woods of Becker, Otter Tail and Douglas counties, it is connected northward with the great forest that overspreads nearly all of northern and north-eastern Minnesota. The west border of the Big Woods crosses Meeker county in an irregular line that has frequent indentations and spurs, passing from the northwest corner of the county south-east and south by Manannah, Forest City and Darwin, to Greenleaf. This boundary between forest on the east and prairie on the west, enters McLeod county at its north-west corner, and runs south-eastward across this and Sibley counties, by Hutchinson, Glencoe, New Auburn and Arlington. Through Nicollet county the forest occupies a width of two to four miles along the west side of Minnesota river to Mankato and South Bend. It also extends in about the same amount along the north side of Minnesota river for 15 miles above Mankato; and Timber lake, 6 miles north-west from St. Peter, is bordered by broad wood lands.

East of this line, the Big woods cover all of Wright, Carver, Scott and Le Sueur counties, excepting small enclosed prairies and the bottom-lands and terraces of modified drift within the valley of the Minnesota river. Beyond South Bend the boundary of this timbered belt is a few miles outside the limit of my exploration. Prof. Winchell, in a former report, states that its course bends eastward in Blue Earth county, passing near Janesville, and about six miles north of Waseca. Thence it turns north-east to Faribault and Cannon City, from which a spur of forest reaches south along the east side of Straight river to Owatonna. The east border of the Big Woods has a nearly north course, passing from Cannon City to Northfield, Lakeville, and the west edge of Minneapolis.

*Limits of Species.* Many trees, shrubs and herbs that flourish northward, have their southern limit at a line north-east and north of the Big Woods; while the forest of Becker, Otter Tail and Douglas counties contains them only in its north-east part. Among these northern species are white, red and gray pines, black spruce, balsam fir, low blueberry, and cranberry. Most of these were seen in the township of Spruce Hill at the north east corner of Douglas county, which seems to be their only occurrence in that county. Thence they are found sparingly northward to the Northern Pacific railroad, beyond which are valuable pineries, beginning at New York Mills, Pine lakes, and Frazee City, and extending indefinitely to the north and north-east. None of these species are found in the Big Woods, which however contain others, as cottonwood, bitternut, wild crab-apple, and frost grape, that are rare or wanting in the northern forest.

*List of Trees and Shrubs.* The following species of trees and shrubs have been observed in Becker and Otter Tail counties, by Mr. R. L. Frazee, manufacturer of lumber at Frazee City, Becker county: white pine (*Pinus Strobus, L.*), red (commonly called Norway) pine (*P. resinosa, Ait.*), and gray or Banks' pine, often called "jack pine" (*P. Banksiana*, Lambert), black spruce (*Abies nigra*, Poir.), balsam fir (*Abies balsamea*, Marshall), balsam poplar (*Populus balsamifera*, L.), paper or canoe birch (*Betula papyracea*, Ait.), and beaked hazelnut (*Corylus rostrata*, Ait.), common north-east from the Northern Pacific railroad; white elm (*Ulmus Americana*, L.), bass (*Tilia Americana*, L.), sugar maple (*Acer saccharinum*, Wang.), box-elder (*Negundo aceroides*, Mœnch), black ash (*Fraxinus sambucifolia*, Lam.), bur and white oak (*Quercus macrocarpa*, Michx., and *Q. alba*, L.), ironwood (*Ostrya Vir-*

*ginica*, Willd.), species of willow (*Salix*), poplar or aspen (*Populus tremuloides*, Michx.), tamarack (*Larix Americana*, Michx.), prickly ash (*Zanthoxylum Americanum*, Mill.), smooth sumac (*Rhus glabra*, L.), climbing bittersweet (*Celastrus scandens*, L.), wild plum, wild red cherry and choke cherry (*Prunus Americana*, Marshall, *P. Pennsylvanica*, L., and *P. Virginiana*, L.), ninebark (*Spiræa opulifolia*, L.), raspberry and high blackberry (*Rubus strigosus*, Michx., and *R. villosus*, Ait.), thorn (*Cratægus*,) Juneberry (*Amelanchier Canadensis*, T. & G.), prickly and smooth gooseberries (*Ribes Cynosbati*, L., and *R. hirtellum*, Michx.,) black currant (*Ribes floridum*, L.), wolfberry (*Symphoricarpus occidentalis*, R. Brown), high bush cranberry (*Viburnum Opulus*, L.), and hazelnut (*Corylus Americana*, Walt.) common generally; slippery or red elm (*Ulmus fulva*, Micheli), black oak (*Q. coccinea*, var *tinctoria*), large-toothed poplar (*P. grandidentata*, Michx.), and black cherry (*P. serotina*, Ehrhart), less frequent; red oak (*Q. rubra*, L.), soft or red maple (*Acer rubrum*, L.), black raspberries (*Rubus occidentalis*, L.), and elder (*Sambucus Canadensis*, L.), scarce; cottonwood (*populus monilifera*, Ait.), seen rarely about the shores of lakes; and hackberry (*Celtis occidentalis*, L.), known only at one place, near Lake Lida.

The Big Woods are principally made up of the following species of trees: white or American elm, bass, sugar maple, black and bur oaks, butternut, slippery or red elm, soft or red maple, bitternut, white and black ash, ironwood, wild plum, Juneberry, American crab-apple, common poplar or aspen, large-toothed poplar, tamarack (in swamps), box-elder, black cherry, cottonwood (beside rivers and lakes), water beech, willows, hackberry, paper or canoe birch, white oak, and red cedar. This list, in which the arrangement is according to the estimated order of abundance, is given by Prof. Winchell for Hennepin county, in his fifth annual report, p. 142; but it appears to be applicable, with slight differences, to all other portions of the Big Woods. Everywhere through this forest the two largest and most plentiful species are elm and bass. Another list of trees and shrubs, noted in passing through these woods in Scott county, is recorded by Prof. Winchell in his second annual report, pp. 210 and 211; followed by a few additional species, as the Kentucky coffee-tree, black walnut, and yellow birch, seen in ascending the valley of the Minnesota river to Big Stone lake.

Timber is found along the Minnesota river in a nearly continuous, though often very narrow strip, bordering the river through almost its entire course; but generally leaving much of the bottom-land treeless. The bluffs on the north-east side of the river have for the most part only thin and scanty groves or scattered trees. The south-western bluffs, on the contrary, are heavily wooded through Blue Earth and Brown counties, excepting two or three miles at New Ulm. They also are frequently well timbered in Redwood and Yellow Medicine counties; but in Lac qui Parle county they are mostly treeless, and have only occasional groves. The greater abundance of timber on the south-western bluffs appears to be due to their being less exposed to the sun, and therefore more moist, than the bluffs at the opposite side of the valley. Above Montevideo the timber is mainly restricted to a narrow belt beside the river, and to tributary valleys and ravines.

About Big Stone lake, timber generally fringes the shore; occurs of larger growth in the ravines of its bluffs; and covers its islands, situated within six miles above its mouth. The speceies of trees observed by Prof. Winchell

near the foot of this lake on its north-east side, are the following in their order of abundance: white ash, bur-oak, bass, white elm, box-elder, cottonwood, hackberry, ironwood, soft maple, wild plum, slippery elm, and willow. The shrubs recorded in the same locality are grape, prickly and smooth gooseberries, wolfberry, black currant, prickly ash, red and black raspberries, elder, sweet viburnum, red-osier dogwood, climbing bittersweet, choke cherry, red and white rose, Virginia creeper, waahoo, and smooth sumac.

Red river has no timber, or very little, for twenty miles east from Breckenridge. In the ten miles next below Breckenridge, it is bordered by scattered groves of bur-oak, ash, box-elder, elm, and bass, occupying perhaps one-fourth of this distance, while small poplars and willows occasionally appear in the spaces between the groves. Farther to the north, this river is continuously fringed with timber, and its larger tributaries have their course marked in the same way. The growth of wood is here confined to the banks of the streams, which have cut hollows 20 to 40 feet deep in the broad lacustrine plain. The trees and shrubs which thus occur along the Red and Buffalo rivers in northwestern Clay county, are stated by Mr. Adam Stein, of Georgetown, to be the following: white ash, white and slippery elm, bur-oak, ironwood, poplar, box-elder, wild plum, hackberry, prickly ash, frost grape, choke cherry, red raspberry, rose, thorn, prickly and smooth goosberries, black currant, and hazelnut, more or less common; wild red cherry, Juneberry, high bush cranberry, and cottonwood, rare.

*Prairies.* The greater part of the region here reported is prairie. This term is commonly used to embrace all tracts destitute of trees and shrubs but well covered with grass. Groves of a few acres, or sometimes a hundred acres or more, occur here and there upon this area beside lakes, and a narrow line of timber often borders streams, as just described along the Minnesota and Red rivers; but many lakes and streams have neither bush nor tree in sight, and frequently none is visible in a view which ranges from five to ten miles in all directions. Most of these prairies have the moderately undulating contour described at the beginning of our remarks on topography. Within the area of Lake Agassiz the surface is almost absolutely level. Other portions of these prairies are quite hilly, having undulations of 100 feet or more, as from Hawley southward along the east side of the lacustrine area to Red river; thence south-east to Pelican lake and Lake Oscar; the morainic hills of Pope county; and parts of Acton, Danielson, and Greenleaf, in Meeker county. If we compare the forests with the prairies as to their prevailing contour, we find that for the most part the former are hilly and the latter gently undulating; yet much of the timbered areas, especially of the Big Woods, is only slightly uneven and occasionally quite level, while some very hilly tracts are prairies. The material of nearly all these areas is closely alike, being till or unmodified glacial drift, showing no important differences such as might cause the growth of forest in one region and of only grass and herbage in another.

The absence of trees and shrubs upon large areas, called prairies, in this and neighboring states, is generally attributed correctly to the effect of fires. Through many centuries fires have almost annually swept over these areas, generally destroying all seedling trees and shrubs, and sometimes extending the border of the prairie by adding tracts from which the forest had been

burned. Late in autumn and again in the spring the dead grass of the prairie burns very rapidly, so that a fire within a few days sometimes spreads fifty or a hundred miles. The groves that remain in the prairie region are usually in a more or less sheltered position, being on the border of lakes and streams and sometimes nearly surrounded by them; while areas that cannot be reached by fires, as islands, are almost always wooded. If fires should fail to overrun the prairies in the future, it can hardly be doubted that nearly all of them would gradually and slowly be changed to forest. Yet it does not appear that fires in forests at the West are more frequent or destructive than at the East, and our inquiry must go back a step further to ask why fires east of the Appalachian Mountains had nowhere exterminated the forest, while so extensive areas of prairie were produced by them in the West. Among the conditions which have led to this difference, we must probably place first the generally greater amount, and somewhat more equal distribution throughout the year, of rain in the eastern states.

The average growth on the dry portions of the prairies of this region would make about a half a ton of hay per acre. It affords magnificent pasturage, but the pioneer farmer gathers nearly all his hay from the frequent depressions or "sloughs," which yield twice as much as the higher land, but of somewhat inferior quality. These are marshes through the spring and early summer, but become mostly dry later in the season, so that horses can be driven across them.

The most abundant grasses found upon the prairies in the vicinity of New Ulm by Mr. B. Juni of that place, are as follows: *Andropogon furcatus*, Muhl., *Sorghum nutans*, Gray, *Bouteloua curtipendula*, Gray, and *Stipa spartea*, Trin., common on portions neither very dry nor very moist; *Andropogon scoparius*, Michx., and *Bouteloua hirsuta*, Lagasca, common on dry swells; *Spartina cynosuroides*, Willd., in sloughs, making the principal mass of their hay; *Leersia oryzoides*, Swartz, with the last; and the stout *Phragmites communis*, Trin., common on the marshy shores of lakelets. The prairies also bear a great variety of flowers. Of asters Mr. Juni finds the most common species to be *Aster surculosus.*, Michx., *A. sericeus*, Vent., and *A. Tradescanti*, L.; of golden-rod (*Solidago*), *S. Ohioensis*, Riddell, *S. Canadensis*, L., and *S. lanceolata*, L. Among the most noticeable and common plants of the prairies, besides the foregoing, are *Liatris spicata*, Willd., *Psoralea argophylla*, Pursh, *Petalostemon violaceus*, Michx., *P. candidus*, Michx., *Amorpha canescens*, Nutt., *Rosa lucida*, Ehrhart, *Campanula rotundifolia*, L., *Phlox pilosa*, L., *Gentiana crinita*, Frœl., *G. detonsa*, Fries., and *Lilium Philadelphicum*, L.

## STRATIGRAPHIC GEOLOGY.

My only observations of rocks older than the drift are confined to the deep valley of the Minnesota river, the topography of which has been already described. The only other exposure of the old rocks known within this area of 16,000 square miles is recorded by Owen, and was seen in his boat journey down the Red river, at a point a little above Fergus Falls. The geology of the Minnesota valley was explored by William H. Keating in 1823; by G. W. Featherstonhaugh in 1835; and by B. F. Shumard in 1848. Soon after the establishment of the present survey, Prof. Winchell in 1873 examined this valley throughout, and his description of it, embracing also notes as to the observations of these earlier explorers, occupies pages 127 to

212 of the second annual report. This treats very fully and completely of all the rock-formations of this valley; and its conclusions have been uniformly confirmed, while indeed very little important information has been added by my journey over the same ground.

The following description of the old rocks is therefore based in large part upon Prof. Winchell's report. They are taken up in their order of age, beginning with the oldest, and including metamorphic granites and gneisses of the great series denominated Eozoic or Archæan; a conglomerate and quartzite, considered of the same age with the Potsdam sandstone; the St. Lawrence limestone, Jordan sandstone, and Shakopee limestone, belonging to the Lower Magnesian or Calciferous epoch, all these above the metamorphic rocks being of the great Lower Silurian series; and various shales, sandstones, limestones, and clays, the latter sometimes holding beds of lignite, regarded together as of Cretaceous age. The St. Peter sandstone and Trenton limestone, of the Lower Silurian series and lying next above the Shakopee limestone, occur in this valley near its mouth, but not within the limits of the counties here reported. The glacial and modified drift come last in this order, being our latest completed geological formation.

*Granites and Gneisses.* These are metamorphic rocks of the series called Eozoic or Archæan, the most ancient known to geology. They are doubtless an extension from the large area of these rocks in north-eastern Minnesota. They are, however, generally covered by drift except in the counties which border Lake Superior, and have only few exposures in the central part of the State. The nearest of these are in the vicinity of St. Cloud, 75 miles from the Minnesota river. It has been already stated that the various rock-formations seen along this river have been uncovered by the excavation of a deep channel through the drift.

The granites and associated rocks of this valley occur frequently through a distance of 100 miles, from a point one mile below the mouth of Big Stone lake to about five miles south-east from Fort Ridgely. In the next 13 miles, no rocks older than the Cretaceous are found. Then comes the last outcrop of granite, opposite the south-east part of New Ulm, succeeded by conglomerate and quartzyte.

No rocks older than drift, excepting some Cretaceous deposits, occur in this valley along Traverse and Big Stone lakes, or in the distance between them. One mile below Big Stone lake, a coarse red granite begins and thence occupies nearly the whole valley for three miles, its highest portions rising 50 to 75 feet above the river. It again appears in low outcrops two and three miles from the last, in secs. 30 and 32, t. 121, r. 45, the first of these being on the north side of the Minnesota a little west of Stony Run, and the second on the south side at Mr. Frederick Frankhaus', a half mile west from the ford. Two to six miles south-east from the ford, in t. 120, r. 45, which extends from the mouth of Yellow Banks river to Marsh lake, similar granite, principally red or flesh-colored but in some portions light gray, forms abundant outcrops, mainly on the south side of the river, rising 50 to 75 feet in their highest portions. North of these, two ledges of this rock were noted about a mile apart, halfway between Odessa and Correll stations, the west one lying a little south of the railroad, while the east one is crossed by it. All the foregoing exposures are massive granite, containing a large proportion of feldspar to which its prevailing reddish color is due.

It is variously jointed, but does not exhibit the lamination which is generally noticeable in the south-eastward continuation of these rocks.

Gneiss has the same composition with granite, being made up of quartz, feldspar, and mica. It differs from granite in having these minerals laminated, or arranged more or less distinctly in layers. Nearly all the metamorphic rocks that remain to be described are varieties of gneiss, with which masses of granite, syenite, and hornblende schist occur rarely. For 15 miles from the upper part of Marsh lake to the middle of Lac qui Parle, we have no report of ledges. In sec. 32, t. 119, r. 42, an island of rock occurs in Lac qui Parle, and two ledges were seen across the lake on its west side. About two miles south-east, or one and a half miles above the foot of the lake, are several small and low exposures of rock, occuring at each side and also as islands. On the north-east side this is gneiss, mostly with N. E. to S. W. strike. Its dip was clearly shown at only one place, being there 75° S. E.

In the deserted channel between Lac qui Parle and the Chippewa river rock is exposed near the south-east corner of sec. 6, Tunsburg. It also occurs at the south east corner of this township, in the bottom-land on the east side of the Chippewa river, three miles above its mouth. Another low exposure is one mile west of Montevideo on the north side of the Minnesota, halfway between the river and the bluff. Close south of Montevideo, a knob of gray gneiss, nearly vertical, with W. S. W strike, rises 30 feet above the bottom-land. One to two miles south-east from Montevideo are extensive outcrops of gneiss, rising 40 to 60 feet and extending one and a half miles from the river to the bluff at its north-east side. At a little lake near the river its dip is 45° S. 10°—20° E. Adjoining this, the gneiss includes a mass of hornblende schist, 20 rods long from north-west to south-east and from 20 feet to 6 rods wide. Its dip is 33° S. E. by S. At the railroad cut the rock is reddish gray gneiss, dipping 45° to 60° S. E. Two to four miles south-east from these outcrops are others of small extent, also on the north side of Minnesota river.

At Granite Falls and Minnesota Falls ledges of gneiss occur on both sides of the river, filling the valley with a multitude of knobs and short ridges 30 to 75 feet high. These rocks begin five miles above Granite Falls, near the mouth of Stony Run. Along this distance they occur principally on the south-west side. In the N. E. ¼ of sec. 24, Stony Run, the strike for an eighth of a mile is S. 80° E., the dip being 75° N. 10° E Generally, however, the strike is nearly N. E. to S. W., the dip being south-easterly. In the north-west edge of Granite Falls, the dip is 60° S. E., but more commonly it ranges between 25° and 40°. In a few places at Granite Falls it is toward the north-east or north. At Minnesota Falls it was noted in one place to be 58° S. 10° E., and near by 85° in the same direction. These are exceptions, while the prevailing inclination is toward the south-east. The strata are reddish or gray gneiss, frequently so disintegrated by the weather that its outcrops have become turfed, varying occasionally to more enduring gray and red granites. These rocks also sometimes include trap dikes, of massive, very heavy, dark green rock, as at the rapids, recently used for manufacturing, one mile above Granite Falls, where two dikes, respectively 20 and 48 feet wide, occur 54 feet apart, their course being N. E. to S. W., conformable with the strike of the rocks. Elsewhere the gneiss may include

a bed or lenticular mass of hornblende schist, as is seen at the east end of Granite Falls bridge and dam. Gray syenite, probably valuable for building and ornamental purposes, occurs about a half mile south from Minnesota Falls. A large specimen of it, elegantly polished, was shown me by Mr. Park Worden of this place. It is composed of white quartz and black hornblende, in nearly equal parts, somewhat schistose as to the direction of its grains. The trap dikes, hornblende schist, syenite and granites, are together but a small portion of these rocks which mainly are gneiss. Its outcrops from Granite Falls to one mile below Minnesota Falls are very prominent, rising in irregular and picturesque confusion throughout the entire valley, nearly two miles wide. Lower ledges continue less frequently for a mile or two beyond these.

The next outcrops noted are six miles down the river, along its portion called Patterson's Rapids, which extend, with frequent intervals of smooth current, seven miles or more, through t. 114, r. 37. The river here divides Sacred Heart on the north from Swede's Forest on the south. In the north-west corner of Swede's Forest, ledges abound for two miles, reaching 40 to 75 feet above the river. A lone school-house is situated among them, near the north-east corner of sec. 18. Half a mile west from this, the rock is reddish gray gneiss, dipping 15° N. N. W. A third of a mile west from it, are massive granite cliffs, divided by joints into nearly square blocks, 10 to 15 feet in dimension. This rock may be found valuable for quarrying. One-eighth of a mile east from the last, it is gneiss, dipping 15° S. At the east side of the school-house, it is also gneiss, dipping about 5° S.

Along the entire river-boundary between Redwood and Renville counties, a distance of 30 miles, ledges of gneiss and granite abound, in some places enclosing masses of hornblende schist. For 12 miles above Beaver Falls they fill the whole valley, occurring on each side of the river, and rising 50 to 125 feet above it. Between Beaver and Birch Cooley creeks the outcrops are mainly on the north side of the Minnesota, rising in their highest portions 100 feet above the river. Below the mouth of Birch Cooley they are mostly on the south side, occurring in great abundance for two miles above and three miles below the mouth of Wabashaw creek. The highest of these are a mile above this creek, rising 75 to 125, or perhaps 140 feet, above the river. It will be remembered that the bluffs along all this part of the valley are about 175 feet high, so that none of these ledges was visible before the surface of the drift-sheet had been considerably channelled. At Birum's mill, on the Redwood river where it enters the Minnesota valley, 1½ miles north-east from Redwood Falls, the rock is a greenish talcose quartzyte, dipping 25° S. E. One mile north-east from this, on the opposite side of the Minnesota and one fourth of a mile north of the ford, the rock is gray gneiss, weathering to reddish gray, apparently almost vertical, with its strike E. N. E. At the east side of the road this gneiss is crossed by a nearly vertical vein, 1 to 3 feet wide, of coarsely crystalline feldspar and quartz, extending within sight 50 feet. These strata are also exposed in the valley of Beaver creek one and two miles above its junction with the Minnesota valley. The Champion mill-dam at the village of Beaver Falls is nearly within the line of strike of the gneiss described north of the ford, and a similar gneiss, with nearly the same strike, is found here. Its dip is 15° S. S. E. At the dam of the O K mill, one mile north-east from the last, is an extensive exposure of

gray gneiss, also with E. N. E. strike; it is nearly vertical, or has a steep dip to the S. S. E., and in some portions is much contorted. Veins, 6 to 18 inches wide, of coarsely crystalline flesh-colored feldspar, coinciding with the strike, are common here. The valley of Birch Cooley, one mile above its entrance into that of the Minnesota, has a large exposure of granite, holding interesting veins, faulted and divided portions of which are figured in Prof. Winchell's report. One of these veins, composed of granite and four inches wide, is traceable 250 feet, running south-west.

Two miles below the mouth of Birch Cooley, a low outcrop examined on the north side of the river is granite, containing a large proportion of flesh-colored feldspar. Ledges were next seen on the north side three miles below the last, in the vicinity of the line between Birch Cooley and Camp, extending a half mile westward from Reikie and Fenske's flour mill. A small outcrop occurs five miles south-east from these, beside a small round lakelet in the bottom-land north of the river. One mile farther south-east, in the west extremity of Ridgely township, and 1½ miles west of Fort Ridgely, are the ledges which supplied the stone used in building the fort. An excavation found near the north end of the outcrop, is in porphyritic granite, which contains abundant gray feldspar crystals, ¾ to 1½ inches long and one third to two thirds as wide; it also contains occasional masses six to twelve inches long and half as wide, mostly made up of black mica in small grains. This ledge is also traversed by several flesh-colored feldspathic veins, 2 to 6 inches wide. The other rock-masses near by are mostly feldspathic granite, flesh-colored, not noticeably porphyritic. In one band here, the rock is hornblende schist and mica schist, much contorted, weathering to a very rough honey-combed surface. This band extends several rods from north to south, and dips 45° to 60° W.

Four miles below Fort Ridgely, at Little Rock creek, which is a mere rill, ledges again appear. They extend one mile from north-west to south-east, lying on the north side of the river, and rising 40 to 60 feet above it. This rock is partly gneiss, much contorted and often obscure in its lamination, and partly granite, both being flesh-colored, apparently from weathering. It is abundantly jointed and seamed. The dip is not clearly exhibited. Prof. Winchell thought, from the outlines and slopes of surface, that it might be 35° or 40° to the north.

Thirteen miles of the valley next to the south-east have no rock exposures. Two small outcrops of granite follow this, lying in the bottom-land of the S. W. ¼ of sec. 27, Courtland. It is a coarse granite, the greater part of it consisting of flesh-colored feldspar. Weathering has made it very friable on the surface, but the interior is solid. This is the last occurrence of the rocks of this series seen in the Minnesota valley. It is about 300 feet west from the south end of a conglomerate outcrop, and one mile northwest from the quartzyte at Redstone.

Examination of these notes as to strike and dip shows that the axial lines of folds in these rocks run mainly from north-east to south-west. Very thorough detailed exploration would be requisite, but very probably, being confined to this narrow valley, would be insufficient to determine the position of synclinal, anticlinal and inverted axes, or to arrive at any stratigraphic divisions of the series. No quarrying of any importance has been yet undertaken in any portion of these rocks in the Minnesota valley; but

they are extensively quarried at St. Cloud, both for building and monumental stone.

*Wells in Metamorphic Rocks.* A well drilled for the railroad, at Herman, Grant county, passed through 124 feet of till, and then went 65 feet in rock. The first seven or eight feet of the rock was the fine grained, buff, magnesian limestone, boulders of which are common throughout northwestern Minnesota. Prof. Winchell thinks it probable that this portion was a compacted mass of boulders. This seems to be the rock which Owen observed in the bank of the Red river above Fergus Falls. His statement shows that possibly it was there only a large slab, embedded in nearly horizontal position in the bank, instead of being in place as a solid bed. This rock outcrops in the vicinity of Winnipeg, in Manitoba. The remaining 57 feet drilled in the rock was through quartzose granite, with red feldspar; white micaceous quartzyte; and mica schist of several varieties.

The section of the salt-well at Belle Plaine was as follows, in descending order: 216 feet of stratified gravels, sands, and clays, all apparently belonging to the glacial period; 16 feet of sandstone; 10 feet of ochreous shale; 176 feet of highly magnesian clays, purple and speckled with white, mostly without siliceous grains; and 292 feet of siliceous, unctuous shale, highly ferruginous, sometimes amygdaloidal, and varying to a micaceous quartzyte. From 216 to 418 feet, the strata are thought to represent the quartzyte and pipestone of Potsdam age, which outcrop near New Ulm and in Pipestone county; from 418 feet to the bottom of the well at 710, they are considered lower than the Potsdam sandstone; but the granites and gneisses lie yet deeper. No other wells in the district here reported penetrate to the metamorphic rocks.

*Decomposed Gneiss and Granite.* Very remarkable chemical changes have taken place in the upper portions of many of the exposures of gneiss and granite near Redwood Falls. The rock is transformed to a soft, earthy or clayey mass, resembling kaolin. It has a blue or greenish color, when freshly exposed; but when weathered, assumes a yellowish ash color, and finally becomes white and glistening. Mica scales and laminæ of quartz are generally contained in this material, and have the same arrangement as in gneiss, so that the dip can be distinctly seen. Veins of quartz or feldspar, the latter completely decomposed, and the lines of joints, are also noticeable, just as in granite or gneiss; making it evident that this substance is the result of a decay of the rocks in their original place. So far as can be judged from stream channels and other exposures, this decomposition reaches in some places to a depth of 20 or 30 feet, perhaps more. All grades of change may be found, from ledges where only here and there a few spots have been attacked and slightly decomposed, to portions where nearly every indication of its origin has been obliterated.

Before the extensive denudation of the glacial period, it is probable that all the granite and gneiss of this region were covered by a similarly decayed surface. Upon the areas where decomposed rocks still exist, the glacial ploughing was shallower than elsewhere. These beds are frequently overlain by Cretaceous deposits, and appear to have been submerged beneath a Cretaceous ocean. Prof. Winchell suggests that their decay may have taken place during this submergence, under the influence of the abundance of alkaline chemical agents held in solution by the sea in that age. Expo-

sures of these kaolinized strata are found in a ravine north of the river opposite Minnesota Falls; in the gorge of Redwood river below Redwood Falls, interesting for its grand and beautiful scenery; in many of the ledges of Minnesota valley for several miles next below, especially in exposures made by roads at the foot of the bluffs; in the valley of Birch Cooley near its mouth; and occasionally for 8 or 10 miles farther down the valley.

*The Conglomerate opposite New Ulm.* This outcrop is about 1000 feet long, in which distance its height rises from 10 to about 60 feet above the river. Its strike or course is N. 20° E., while the dip, measured by Prof. Winchell, is 18° E. S. E. Its greatest exposure vertically at any one place is about 20 feet. The beds vary from 1 to 6 feet in thickness. It is a massive, tough conglomerate. The pebbles in it are all more or less water-worn; they are generally abundant, often occurring nearly as thick as they could be packed. They are of all sizes up to a diameter of one foot or a little more. These pebbles are remarkable as consisting, almost without exception, of only two kinds of rock, which occur together in nearly equal abundance and dimensions. One of the two classes is apparently a jasper, usually dull red and massive, but in many of the fragments laminated, or in thin bands, which are sometimes dark, sometimes yellow; the other class is white quartz, massive, now and then containing foreign particles, and occasionally smoky in color. The origin of this conglomerate may have been from the action of sea-waves upon a coast where only these two kinds of rock were exposed. The only pebble found, which could not be referred to these classes, was a scrap of fine-grained gneiss, two inches long. Neither the granite that outcrops close at the west, nor the quartzyte that occurs upon a large area at a mile to the east, seems to be represented. The conglomerate is probably older than the quartzyte, but both are thought to come within the Potsdam epoch.

*The Quartzyte at Redstone.* This lies on the north-east side of the river, beginning at the Redstone railroad-bridge, and extending one mile to the east and south-east. The highest knobs of its southern part rise 100 to 125 feet above the river, while its most northern part forms a nearly level tract of about equal height, ¾ of a mile long, lying at the south side of the carriage road. The greater part of this outcrop dips northerly. South of the west railroad-cut the dip is 27° N. 10° E. At another cut, a third of a mile east from this, it is 45° N. N. E. It frequently varies as much as 10° within a few rods, and its north portion seems to be nearly level in stratification. The thickness exposed in the whole outcrop may be 250 feet. The rock is a compact hard quartzyte, of red or reddish gray color. It is variously divided by joints, and its solid masses often have a tendency to break into rhomboidal fragments. The layers are 3 to 12 inches thick, mostly without lamination at the north; but at the south-west they show fine laminæ, part of which are shale softer than the rest of the rock. At the north-west it rarely encloses small pebbles, the largest seen being three-quarters of an inch in diameter. They include only red jasper and white quartz, like those of the conglomerate just described. Stone suitable for cellar-walls and foundations is quarried from this formation.

*St. Lawrence Limestone.* Eleven miles south-east from the quartzyte, we find at Hebron and Judson the first exposure of the Lower Magnesian rocks within the Minnesota valley. Thence to the limit of our survey at Hamilton

these rocks occur frequently. They consist of three members, named in ascending order the St. Lawrence limestone, Jordan sandstone and Shakopee limestone, from the lowest places in this valley at which they are well exposed.

The St. Lawrence limestone at Hebron extends from Nicollet creek, the outlet of Swan lake, about 1½ miles eastward It rises 25 to 35 feet above the river, against which it forms a barrier, protecting a broad terrace of modified drift that lies between the limestone exposures and the foot of the bluffs. Its stratification is nearly level, the dip being about 2° to the south-east. The beds are 1 to 4 inches thick at top, where it has been affected by weathering; below they are 4 to 12 inches thick. The rock is a fine-grained compact magnesian limestone, yellowish or reddish gray, often streaked or speckled with green. Its layers are generally separated by a thin film, or sometimes by a seam ½ inch thick, of dark green crumbling sandstone. The upper part of these beds in the race-way of the Hebron stone-mill contains a layer of soft sandstone one foot thick. Several quarries are worked slightly on each side of the river.

Other exposures of this limestone in the Minnesota valley are few. It is next recognized in two low outcrops, a mile apart, at the east side of Sibley county, 30 miles from Hebron in a straight line. The first is on land of Henry Young, in the south part of sec. 13, Jessenland. The rock is yellowish buff limestone, nearly level in stratification, in layers 1 to 4 inches thick, much divided and broken by vertical and oblique seams and cracks. A half dozen kilns of lime have been burned from this rock within the past two years. The second outcrop is owned by Walter E. Doheny, and lies in the south-west corner of Faxon, only a short distance from the town line and river. Its extent, height, stratification, and jointed condition are nearly the same as in the last. It is a dull red, slightly arenaceous limestone. A quarry seven feet deep shows layers 1 to 5 inches thick, often separated by thin earthy seams.

In St. Lawrence, 10 miles north-east from the foregoing, this limestone occurs occasionally for a distance of nearly two miles, having its top about 45 feet above the river. It is nearly level in stratification, in beds from 2 to 18 inches thick. The color is buff, reddish, or yellowish gray, usually with frequent green specks. In composition it is a siliceous magnesian limestone. It has been considerably quarried, and supplies good building stone. A vertical thickness of about 15 feet is seen in quarries and natural exposures; and wells here have drilled into it 24 feet, without reaching its base.

The reference of all these outcrops to a horizon below the Jordan sandstone is based on their lithological character, and on the position and stratification of neighboring rocks belonging higher in this group. At Jordan, 3 miles east from St. Lawrence, wells encounter the St. Lawrence limestone, pinkish buff in color and very compact and hard, lying directly beneath the soft and friable Jordan sandstone. At the upper brewery the well was 12 feet deep, 10 feet in sandstone and 2 feet in limestone. The well of the lower brewery, 11 feet deep, was dug 6 feet in sandstone, and then 5 feet in this very hard limestone. Below this it was drilled 25 feet, all the way in limestone, which was thought to grow harder; its base was not reached. The limestone also occurs in the bed of Sand creek, at the pier of the private bridge in front of the lower brewery. All these exposures of St. Lawrence

limestone in the Minnesota valley probably exhibit its upper portion, and its thickness here remains undetermined. In Fillmore and Houston counties it is about 200 feet thick, forming more than half of the Lower Magnesian group.

*The Jordan Sandstone.* Next above the last is a coarse-grained sandstone; white or light gray, or often somewhat stained with iron-rust. It is usually soft and crumbling, so that it is readily excavated with a shovel; but some of its beds, quarried at Jordan, yield stone sufficiently durable for the construction of large mills and bridge masonry. It becomes harder upon exposure to the air, and its ledges sometimes have an indurated surface while they are quite friable within. The stratification is level or nearly so, in beds that vary from six inches to 3 feet in thickness. While each of these layers is plainly horizontal, its lamination is frequently oblique, being inclined 5° to 20°. This structure is the same with that often seen in recent sand-deposits, where the material was spread and arranged by strong currents. The direction of this inclination is variable, and seems to indicate the action of tides or waves in water of no great depth. This sandstone, however, extends over a large area, with a comparatively uniform thickness, which is 40 or 50 feet in the Minnesota valley and 25 to 40 feet in Fillmore and Houston counties.

In the vicinity of Mankato this sandstone underlies the Shakopee limestone at the quarries upon each side of the river. They also occur in the same manner, forming bluffs, at Kasota, St. Peter, Ottawa and Louisville, as will be more fully described in speaking of the limestone.

Very extensive exposures of the Jordan sandstone are seen beside the river-road in Oshawa, extending 3 miles above St. Peter. It is easily disintegrated, which often causes slightly harder layers near the top to overhang. Many excavations, used for the same purpose as cellars, have been made in these cliffs. This sandstone also forms the foot of the bluffs at the south side of a creek that enters the Minnesota at the north-east corner of Traverse township. At these places the sandstone rises 40 or 50 feet above the river, and is capped by Shakopee limestone, less conspicuously exposed.

In Lake Prairie the sandstone is seen at several places, as in a ravine crossed by the river-road nearly opposite Ottawa, and at Patrick Osborn's and Frank Linter's, within 1½ miles farther north. Its top in all these localities is about 35 feet above the river; and at Mr. Osborn's the Shakopee limestone is seen overlying it. At and near Mr. Linter's the sandstone forms three outcrops, not protected by its usual cap of limestone. The well here went through soil and drift, 5 feet; gray and white sandstone, 25 feet, sand, 10 feet, an unconsolidated layer of this stone; and white sandstone, as above, 10 feet. Water comes at the bottom, which is probably near the underlying limestone.

At Jordan this sandstone forms numerous outcrops for three-fourths of a mile along the valley of Sand creek. The St. Lawrence limestone is found beneath it here, as already described. The stratification at this place is horizontal, and the exposures are between 35 and 75 feet, approximately, above the river. Here and in several outcrops of this rock occurring within 6 miles northward in the Minnesota valley, the overlying Shakopee limestone is wanting. Four miles from Jordan, in the south edge of Louisville, are extensive exposures of the sandstone, rising about 40 feet above the river.

At the highway bridge over Van Oser's creek, these beds dip 15° W. N. W., owing to some local disturbance which does not generally affect this area. Little Rapids in the Minnesota river, one and a half miles to the west, is caused by two nearly level outcrops of this sandstone.

*The Shakopee Limestone.* This highest member of the Lower Magnesian group is seen at many places overlying the stratum last described. It is a magnesian limestone of buff color, often mottled in alternate red and yellow tints. The stratification is nearly level in beds from a few inches to three feet or more in thickness. In some places, as at Kasota, in the Asylum quarry at St. Peter, and at Mankato, a part of these beds are compact and supply an excellent stone for every purpose in building or monumental work; but generally this rock is much broken by little hollows and crevices, and is of unequal texture, some portions being especially sandy or coarse in grain, or having contorted and obscure lamination. It is burned extensively for lime at Mankato, Caroline station, Ottawa, Louisville and Shakopee. The only observation of any rock lying upon this limestone in the Minnesota valley is at the Asylum quarry, where Prof. Winchell found it covered by two feet of white friable sandstone, with a thin strip of green shale about midway in it. This is supposed to be the St. Peter sandstone, which is known to be next in stratigraphic order above this limestone; it may, however, be a Cretaceous deposit. The Shakopee limestone in the Minnesota valley varies in thickness from about 50 feet thus indicated here to 70 or 80 feet at Shakopee; in Fillmore county it is about 75 feet; in Wilmington, Houston county, it has been found to be 64 feet.

In Belgrade, opposite Mankato, about 40 feet of Shakopee limestone are exposed, affording valuable quarries. In a ravine about 25 rods west of the principal quarry here, the underlying Jordan sandstone is seen for 7 feet vertically, its top being about 30 feet above the river. At the quarries in the north part of Mankato, 50 feet of limestone is shown resting upon the Jordan sandstone at about 25 feet above the river. A terrace of these strata, averaging a mile in width and 75 feet in height above the river, extends thence 7 miles northward to Kasota; beyond which it is continued in decreasing height on the other side of the river through St. Peter. The railroad well at Kasota station went through drift, mostly limestone gravel, 8 feet; solid limestone, 21 feet; and sandstone, 6 feet. Here and generally in this vicinity, the base of the limestone is about 40 feet above the river; but it sinks to about half this height in going 1½ miles northward in St. Peter, between the railroad bridge and the highway bridge.

Ottawa is situated on another terrace of Shakopee limestone underlain by Jordan sandstone. Their junction in the bluff near Charles Schwartz' limekiln, called White Rock bluff by Dr. Shumard, is about 45 feet above the river. The terrace generally rises 20 or 25 feet higher, which is probably the average depth of the limestone remaining here.

The next extensive exposures of the Shakopee limestone are found in Louisville, 30 miles farther down the valley. Quarries which supply good stone for foundations and bridge masonry are worked here on land of Mrs. M. A. Spencer, 1½ miles south-east from Carver. Here the limestone has a thickness of about 30 feet, and 4 feet of the Jordan sandstone is visible below it, their junction being at 12 or 15 feet above the river. This is the lowest point in the valley at which the Jordan sandstone has been seen. A terrace

of this limestone, 40 to 50 feet above the river, extends thence two miles northward. The St. Paul & Sioux City railroad is built upon this; and close at its east side another terrace, formed by the upper part of this limestone, rises 40 feet higher. A quarry in its top half supplies rock for lime-burning at a point a half mile east from the Spencer quarry. A level-topped outlier of the upper terrace occurs 50 rods south-west from these lime-kilns.

At Shakopee the limestone rises from the river's edge to a height of 50 feet, its upper 20 feet being quarried for lime. Beneath the terrace of sand and gravel at the south and south-east, commonly called "Shakopee prairie," the limestone is found at a depth of 40 or 50 feet, its top being 60 to 70 feet above the river. Water is obtained in the wells on this terrace only after drilling 60 to 80 feet in the limestone. Thus Major H. B. Strait's well, 122 feet deep, is soil and sand, 8 feet; clay, 30; limestone, 84, its last 5 feet being light gray in color; water abundant, rising 9 feet. J. A. Wilder's well, 112 feet deep, is soil, 2; yellow stratified clay, 5; sand and gravel, interstratified, coarsest below, 38; hard limestone, 61; quicksand and sandstone, 2 feet, containing plenty of water, which does not rise; "flint rocks," 4 feet. These are within the incorporated limits of Shakopee. Amos Riggs' well, 1½ miles south-east from these, in the S. E. ¼ of sec. 18, Eagle Creek, is 115 feet deep, in order as follows: soil, 2; sand and fine gravel, 38; very coarse gravel, with pebbles up to 1½ feet in diameter, 10 feet; rotten sandy limestone, picked, 5 feet; limestone drilled, nearly all alike, 60; water comes abundantly at 107, not rising.

Four miles east of Shakopee, on land of Thomas Durose, sec. 3, Eagle Creek, this limestone has a low outcrop near the river, which has been slightly quarried. About six miles farther east, at Hamilton, is the lowest point at which the Shakopee limestone is seen in the Minnesota valley. Here it occurs for about 50 feet along the bottom of the raceway of Quinn Brothers' mill, at a height of 20 or 25 feet above the river. Farther east this limestone sinks below the level of the river, and the bluffs of Fort Snelling and its vicinity are composed of the overlying St. Peter sandstone capped by Trenton limestone.

It is interesting to note the nearly level position of these very ancient strata, which have scarcely suffered any disturbance since their deposition. Alternately beds of limestone and sandstone were accumulated upon the floor of the Paleozoic sea, and they have been lifted 600 to 1000 feet or more without being broken or tilted. The height above sea of the base of the Shakopee limestone where it has been observed within the Minnesota valley, is at Mankato, 780 to 795; at Kasota, about 785; at St. Peter bridge, about 760; at Ottawa, 780; and at Louisville, about 720. The distance included is 45 miles in a straight line.

The Lower Magnesian group in this valley is nearly destitute of fossils. In the Shakopee limestone, Prof. Winchell found *Orthis* at Mr. Clapp's quarry for lime-burning in the S. E. ¼ of sec. 17, Kasota; and Dr. Shumard found *Lingula Dakotaensis* and trilobite fragments at Kasota, and the same, with another species of *Lingula* and an *Orthis*, at the White Rock or Ottawa bluff. In the Jordan sandstone, Dr. Shumard found *Straparollus Minnesotensis* a mile above Traverse des Sioux and again at Kasota.

*The Cretaceous.* The first important exposures of Cretaceous beds found in descending the Minnesota river, are in the valley cut by the Redwood

river below Redwood Falls, where a lignitic bed of clay or shale has been explored by a drift to the distance of 40 feet. This bed varies from 7 to 2½ feet in thickness. It is a nearly black, more or less clayey deposit, and contains much lignite of two kinds, one pulverized or in small fragments, resembling charcoal, the other hard and compact, in larger lumps, appearing like cannel coal. In the bank of Crow creek, 3½ miles below Redwood Falls, beds of the same character, 4 feet or more in thickness, and containing leaf impressions, have been explored by drifting some 200 feet. They also occur and have been somewhat tested in several other ravines in that vicinity. A similar coaly layer, 1½ feet thick, has been tunnelled into 40 feet upon the east side of Fort creek, a third of a mile east of Fort Ridgely. No compact, continuous seam of coal has been yet found in any of these beds, though much search has been made. The fragments obtained are insufficient in amount to be of any practical value. They are the same with the pieces of "charcoal" and "stone coal" that are sparingly scattered in the drift throughout all south-western Minnesota, so that frequently one or two are found in digging a well. The origin of these pieces, which vary in size up to 3 or very rarely 6 inches in diameter, is from beds like the foregoing that have been ploughed up by the ice-sheet. It appears nearly certain that no workable coal deposits exist in this region.

Sandy marl, horizontally stratified, probably Cretaceous, is seen in the lower part of the bluff below the Lower Sioux Agency, three miles south-east from Crow creek. Two miles farther east, on the north side of the river, concretionary marl or limy earth, nearly white, occurs in the banks of a small creek about three-quarters of a mile from its entrance into the Minnesota valley. An overlying bed of similar material, colored and hardened by iron-rust, is exposed 18 feet vertically.

In New Ulm the grading of Third North street close north-east of the railroad, exposes Cretaceous clays. This cut is 14 feet deep and 200 feet long. Its upper 4 feet are soil and drift, containing and overspread with many boulders of granite, gneiss and schists, up to 6 feet in diameter. The remaining 10 feet are curved, contorted, and irregularly interstratified, red, yellow, green and gray clays. They are free from gravel, but contain flat, limy concretions, in some portions abundant up to one inch in diameter, and elsewhere joined in sheets a foot or less in length and a half inch or less in thickness, conforming with the stratification. These strata are eroded and covered unconformably by the drift. The terraces on which New Ulm is built have a surface of drift, mostly stratified gravel and sand, 10 to 20 feet thick; underlain by beds that are probably of Cretaceous age, consisting of fine blue clay, bedded, weathering white, 4 to 10 feet thick, and sand or fine gravel, readily crumbling and containing rounded lumps of a fine white powder, exposed 20 to 30 feet vertically. Deposits of clay, which have been much used for the manufacture of fire-bricks and pottery, occur in the banks of the Waraju or Big Cottonwood river south-west of New Ulm. These with associated sandy marl, sandstone, and thick beds of sand, are probably Cretaceous deposits. Other beds of this period, consisting of cavernous and nodular gray limestone, much of which has been burned for lime, interstratified with green and red clay and shale, occur on the north side of the river about a mile below New Ulm, being half way between the conglomerate and quartzyte, and again a mile farther south-east on the

south side. In each place these strata form a terrace about 35 feet above the river.

Eight miles below New Ulm on the north side of the river, Cretaceous sandstone has been slightly quarried on land of William Fritz, in the N. E. ¼ of sec. 16, Courtland. It lies in layers from 1 to 6 feet thick, some of which contain fragments of wood, charcoal, and angiospermous leaves. Interstratified with these layers are others, 6 inches to 3 feet thick, of white uncemented sand. Several outcrops are found here and others appear occasionally for a mile south-eastward, varying in height from 25 to 40 feet above the river. The same rock occurs again on land of Henry Greenholtz, 3 miles south-east from the last, in sec. 24, Courtland, and has been quarried a little for culverts and cellar-walls. Its outcrop is 30 rods south-east from his house, and about 35 feet above the river. There is an irregular slope at each of these localities, amounting to about 50 feet in ¼ mile or less, between the foot of the bluffs and the river.

All the strata here described and referred to the Cretaceous age, lie in a nearly horizontal position beneath the drift. They have only yielded fossils in a few places, and these have been mostly obscure plant remains and lignite. Similar formations, containing characteristic Cretaceous fossils, have a great development in the region drained by the upper Missouri river.

The Shakopee limestone at Mankato, St. Peter, and Ottawa, contains in its cavities and fissures singular deposits of greenish or bluish clay, which becomes white by exposure to the weather. At the railroad bridge across the Blue Earth river, a cut in this limestone shows hollows and crevices reaching 20 feet below the top of the rock. These cavities are water-worn, and their surface is thinly covered by iron ore, from a half inch to an inch and a half thick. Within them, after this ferruginous crust was formed, clay has been sifted and packed so as to fill irregular spaces, often several feet in diameter, enclosed and partially covered by the limestone. The clay here is greenish or bluish, weathering white, in some portions sandy, horizontally bedded, or conforming somewhat to the shape of the hollow that holds it. The quarries at St. Peter contain in clefts and water-worn cavities a similar greenish white silt, holding much sand and many angular flinty fragments. At Ottawa, John R. Clark's quarry exposes a nearly vertical seam of this clay, 1 to 2 feet wide, 6 feet deep and extending lower, seen here for 8 rods in a nearly west-to-east course. Nearly in the line of its continuation, at 25 rods farther east, the same clay was found in Charles Needham's well, in a similar seam, reaching down 15 feet in the limestone. At St. Peter and Ottawa no marks of stratification can be seen. None of these clays have yielded any fossils. Their probable origin has been shown by Prof. Winchell, who attributes them to deposition while this region was deeply covered by the Cretaceous ocean.

*Glacial Drift.* The presence at many points in the Minnesota valley of decomposed granite and gneiss, and of Cretaceous beds, both of which would yield readily to eroding agencies, shows that the moving ice-sheet did not everywhere plough up all the loose material under it. A considerable depth, however, has probably been removed; and these may be scanty remnants of thick beds which covered this region generally before the glacial period. More commonly the ice-sheet removed all such material, and gathered a part of its drift from the underlying solid rocks; as is shown by th

frequently rounded, smoothed, and marked with parallel furrows and scratches, called striæ. Similarly scratched pebbles and boulders are found in the glacial drift. These were the graving tools by which the bed-rock was worn and striated. They were held firmly by being frozen in the bottom of the ice and were pushed forward by its current, which thus recorded its direction. Our observations of striæ are of course limited to the rock exposures seen along the Minnesota valley, and there many of the rocks are so disintegrated by the weather that these marks are effaced.

*Courses of Striæ in the Valley of the Minnesota River,*
referred to the true meridian.

| Locality. | Formation. | Course. |
|---|---|---|
| 1 to 3 miles S. E. from foot of Big Stone lake,........... | ......Granite,..... | ..S. E. |
| F. Frankhaus', S. E. ¼ of sec. 32, t. 121, r. 45,............ | ......Granite,..... | ..S. E. |
| S. E. part of Granite Falls, on N. E. side of river, at several places,.......................................... | .......Gneiss,...... | ..S. 45° -50° E. |
| Beaver Falls, at dam of O K mill,..................... | .......Gneiss,...... | ..S. 60° E. |
| 2 miles below Birch Cooley creek, N. W. ¼ of sec. 10, t. 112, r. 34,.......................................... | ......Granite,...... | ..S. 60° E. |
| 1½ miles west from Fort Ridgely,...................... | ......Granite,...... | ..S. 60° E. |
| Redstone, 1½ miles S. E. from New Ulm,................ | .....Quartzyte,.... | ..S. 25° E. |
| Jordan, observed at several places by Foss, Wells & Co., in quarrying and on site of their mill................. | Jordan Sandstone, | ..S. E. |

In the topographic description of this region it has been pointed out that this valley lies nearly midway between parallel terminal moraines, which extend from north-west to south-east, about 80 miles apart; that on the north-east reaching from the Leaf hills to Glenwood, Minnetonka lake, and Rice county, and that on the south-west being the well-known massive Coteau des Prairies. These series of drift-hills are connected by a loop that passes through Hancock, Kossuth and Palo Alto counties in northern Iowa, making a single contemporaneous series shaped like the letter **U**, and bounding the area covered by a vast lobe or tongue of the ice-sheet. Near the center of this area the glacial current, as shown by these striæ, was in the direction of its axis or south-easterly; but in approaching its margin we must suppose that it was everywhere deflected to a course nearly perpendicular to its terminal moraine. The straight trunk and divergent branches of a tree may illustrate our idea of the axial and marginal motions of the ice-fields upon this area. The terminal moraine accumulated at their border has been described under the head of topography, so far as it has yet been explored.

The most remarkable features of our glacial deposits are their great depth and extent. It has been already stated that the old rocks are almost everywhere concealed; nor are they reached by the deepest wells, which go down 75 to 250 feet without passing through the drift, except in two or three instances, upon this entire area of 16,000 square miles. Through all this part of the State the drift probably averages as deep as along the course of

Minnesota river, where a channel cut down in many places to the older rocks shows these superficial deposits to be from 100 to 200 feet thick. We are not yet able to estimate what portion of this material was here before the glacial period, in the form of decomposed and in part solid rock, Cretaceous strata, mostly unconsolidated, and the alluvium of rivers. The aggregate of these was great, but it seems probable that this thick drift-sheet includes in addition to these materials an equally large amount brought by the ice-current from areas farther north.

Till, or unmodified glacial drift, known also as hardpan or boulder-clay, consisting of clay, sand, gravel, and boulders, mixed indiscriminately together, makes up nearly the whole of this great mass of superficial deposits; excepting the lacustrine plain of the Red River valley, filled by Lake Agassiz during the retreat of the ice-sheet, and the east part of Becker and Otter Tail counties, which are mainly modified drift. Very finely pulverized rock, forming a stiff, compact, unctuous clay, is the principal ingredient of the till upon this area, whether at great depths or at the surface. The admixture of sand and gravel is somewhat variable, being often greater in the upper than in the lower part of the till. It is rarely enough to cause the side of a well or cellar to fall down at the time of excavation. Layers of sand and gravel are frequently enclosed in the till. They are commonly from a few inches to a few feet in thickness, and often are filled with water. At considerable depths the water is generally under hydrostatic pressure, which causes it to rise in wells to within 10, 20 or 30 feet below the surface, sometimes even overflowing. Thick beds of stratified gravel, sand and clay, varying from 10 to 50 or 75 feet, also occur occasionally below till, which is again found beneath them where these stratified deposits have been penetrated.

The till is also found, even where not so divided by intercalations of modified drift, to be in massive beds which differ from each other as to color, hardness, and relative proportions of clay, sand, and stones, these changes being often noticed together at a definite line. The most notable distinction in color is that the upper part of the till, to a depth that varies from 5 to 50 feet, but is most commonly between 10 and 30 feet, is yellowish, due to the influence of air and water upon the iron contained in this deposit, changing it from the protoxide state to hydrated sesquioxide. At greater depths the color is much darker and usually bluish. In a few instances a yellow bed of till is reported beneath or enclosed in the blue till. Several observations show that the yellow color of the till, in its upper portion, has been mainly produced by exposure to the weather since its formation, and was not probably occasioned by differences in the conditions of its accumulation in and beneath the ice-sheet.

Another important difference in the till is that its upper portion is more commonly softer and easily dug with a shovel, while below there is a sudden change to a hard and compact deposit, which must be picked and is often three times as expensive for excavation. There is frequently a thin layer of sand or gravel between these kinds of till, which have their division line at a depth that varies from 5 to 30 or very rarely 40 feet. Owing to the more compact and impervious character of the lower till, the change to a yellow color is usually limited to the upper till. There are instances, however,

where this weathering has not reached to the line that divides the softer from the harder till, and others where it has extended considerably lower. The probable cause of this difference in hardness was the pressure of the vast weight of the ice-sheet upon the lower till, while the upper till was contained in the ice and dropped loosely at its melting.

Again, in numerous places the upper till as here described is directly underlain by a softer till, moist and sticky, and dark bluish in color. This is usually of considerable thickness, or between 20 and 50 feet. It often encloses or is underlain by beds of water-bearing sand; but occasionally it has been penetrated and is found to lie directly upon a bed of very compact till, such as usually comes next below the upper till. In some cases this soft and moist deposit is evidently stratified clay, free from gravel or only holding here and there a stone, and all varieties appear to be found between this and an unstratified and very pebbly till; as indeed it may be that the latter in different localities shows all gradations from its occasionally very soft character, where a shovel can be easily thrust into it to the depth of a foot or more, to the hardest deposits of the lower till in which a pick can be driven only an inch or two at one blow.

The few beds found in this district which contain shells or trees that flourished in interglacial epochs, lie beneath two distinct beds of till, the lower sometimes showing its usual hard and compact character, but elsewhere being even softer than the upper till.

Excepting the division into beds as before described, the till is an entirely unstratified deposit. There has been no assortment by water of its materials, and the coarsest and finest are mingled confusedly in the same mass. Often a thickness of fifty feet or more exhibits no evidence of stratification.

Small rock-fragments, varying in size up to the dimension of six inches, are usually numerous and scattered through all parts of the till; they are, however, seldom abundant, and are sometimes so few that in well-boring none might be encountered. Boulders of larger size are less frequent, and often a well or even a railroad cut in till fails to display any of greater diameter than 2 or 3 feet. Again several may be found of various sizes up to 5 or perhaps 7 or 8 feet. They appear to be usually more numerous in the upper part of the till than below. The number of boulders over one foot in size to be found generally upon the surface varies from one or two to ten on an acre; but often they are more scarce, so that perhaps a dozen could not be gathered on a square mile. Terminal and medial moraines usually contain both small and large boulders somewhat more abundantly, and very rarely they are so plentiful as to cover half the ground; their greater numbers being the most important difference between the till forming the morainic hills and that spread in gently undulating or nearly level tracts.

The largest boulder seen in the first seven weeks of my exploration for this survey was on the hills of Langhei, the highest in Pope county. It measured 12 by 9 feet, and rose 3 feet above the surface, probably having an equal amount buried. This was the only boulder seen during this time that exceeded eight feet in diameter, though the area traversed was almost entirely till and included the Leaf hills and the continuation of this moraine for 100 miles thence to the south and south-east. Larger blocks than the foregoing were seen only in the valley of the Minnesota river, the most

notable being in Big Stone county, where two boulders, about 30 and about 20 feet in diameter, lie near the railroad between Correll and Odessa stations. Nearly all the large boulders throughout this whole region are granite or gneiss, with occasionally one of some crystalline schist or of magnesian limestone.

The thick and almost universal mantle of drift prevents a reference of the varieties of these rocks to their sources. In general, the great representation of metamorphic rocks indicates that these probably occupy the greater part of this area, extending in a wide belt from the Minnesota river to their large tract in the north-east part of the State. The limestone, belonging to a period later than that of the St. Lawrence and Shakopee limestones, quite probably occurs in place beneath the drift in the north-west part of the region here reported, as is indicated by the well already mentioned at Herman, by Owen's note of limestone on the Red river above Fergus Falls, and by the great abundance and large size of its boulders at localities near Audubon and White Earth Agency in Becker county. Northward it outcrops near Winnipeg, and many of its boulders in our drift may have been carried this distance of 200 miles or more in the ice-sheet. The proportion of limestone through the north-west part of our district averages one-tenth or less of boulders exceeding a foot in diameter, while of small pebbles it often constitutes half in bulk and more than half in number. Handfuls of pebbles taken from stratified drift at Hawley, in Clay county, showed 125 of limestone, with 70 of granites and schists; at Muskoda, they were 44 and 36; five miles north of Breckenridge, two-thirds of the pebbles in a gravel bank beside the Red river are limestone. South-eastward a less proportion of limestone is generally found, and its abundance as boulders or pebbles seems to be confined to occasional areas a few miles or less in extent.

Records of wells, noting the order, thickness, and character of the various strata passed through, have been gathered in every part of the region here reported. The total number of wells thus noted is 582. Of these 97 are in localities which showed only modified drift; about an equal number left off in the upper till, or in beds of modified drift lying below it, without going deep enough to reach the lower till; about 30 were recorded because of their sudden rise of water, or for some other reason, without obtaining any particulars as to the material penetrated; and a few were in the rock-formations of the Minnesota valley; leaving 354 wells that show both the yellow and blue tills, in which the depth of the change of color, the occurrence of intercalated layers of modified drift, and generally the relative hardness of the upper and lower tills were noted. Of the last class, 182, or more than half, found the lower till notably harder than the upper till; and of this number, 53 had a layer of sand or gravel between these beds of boulder-clay. The yellow color is almost always limited by the line or stratified beds between these tills; and where the stratified drift is wanting, a sudden and well-marked change is noticed in hardness, color, and often in material.

Soft and moist, dark bluish till, stony and unstratified, underlies the upper till in 45 instances, in 9 of them being separated from the upper till by sand and gravel from 2 inches to 4 feet thick. Two of these beds of lower till had their first few feet hard and were soft below. In 21 other instances there were found beds of more or less plainly stratified, soft, dark bluish clay, which sometimes was free from all pebbles, and elsewhere was quite

pebbly, or, though generally free from gravel, yet contained rarely stones of various sizes up to one foot in diameter. Of these 12 lay directly below the upper till, and 9 were below both this bed and another of hard and compact lower till. The thickness of these beds of till or of stratified clay varies from 5 to 65 feet; in 30 cases it exceeded 25 feet.

The average thickness of the upper till in 256 wells where it is underlain by much harder lower till, or by beds of modified drift, is 17 feet. The extremes are 3 to 5 feet and 40 feet. Examples were found where both the thinnest and thickest of its beds were underlain here by modified drift and there by typical lower till. About a quarter part of the deep wells in till found no noticeable difference between its upper and lower portions except that of color.

Water-bearing gravel and sand, lying in a nearly horizontal layer from a few inches to five feet in thickness, were found in 148 instances at depths in the lower till varying from 30 to 265 feet. The water almost always rises from these beds, sometimes very suddenly and with much force. At Audubon, in Becker county, water was struck at 60 feet, after boring through compact till, and its pressure was so great that it instantly threw up the auger and shafting, weighing 600 pounds, twenty feet, filling the boring with gravel to that height. In three minutes it rose and stood at two feet below the surface. Two wells in Hamden, a few miles to the north, about 75 and 100 feet deep, find water at the bottom which rises and permanently overflows. Other flowing wells are found in Wilkin, Traverse, Grant, Douglas and Chippewa counties. The deepest well found is that bored for the railroad at Stewart, in McLeod county, where the water rises from a depth of 265 feet and stands at 5 feet below the surface. In most places a sufficient supply of water for common needs seeps into the well from the lower part of the upper till or is furnished by springs found in thin seams of sand or gravel next below this, or within 15 or 20 feet in the lower till. The water in these wells usually rises slowly, allowing plenty of time for walling them; or often it is under no pressure, and a reservoir must be dug below its source. The experience of well-diggers frequently demonstrates that veins of gravel and sand filled with water under pressure may be quite narrow. Thus of several wells near together one only will encounter the vein, though the others go much deeper. The upward pressure and abundant supply of water, however, show that though narrow the vein is continuous through a considerable distance and descends from a higher level. It is probable that many of these courses of gravel and sand were formed by small sub-glacial streams.

Stratified beds of gravel, sand or clay were found between the upper and lower till, or lay beneath the upper till and were not passed through, in 127 wells; 77 of which showed 2 feet or less of this modified drift; 22 had between 2 and 10 feet; 7 between 10 and 20; and 21 had from 20 to 70 feet. The thickest of these beds were seldom penetrated. The west range of townships in Otter Tail county may be mentioned as a tract in which such large deposits of modified drift are frequently found under a comparatively thin surface of upper till.

Massive deposits of stratified gravel and sand in or beneath the lower till were found in 43 wells. The lower till above the modified drift in these wells averages 26 feet thick, its extremes being 5 and 53 feet. The under-

lying gravel and sand, with layers of clay in some instances, average 17 feet, and range from 5 to 70 feet in thickness.

Interglacial epochs, in which animals and plants lived upon this area, are proved by their remains preserved, evidently where they were living, in stratified beds underlain and overlain by till. Such fossiliferous beds, however, are very rarely found in this region, and the following enumeration includes all that have come to our knowledge. In sec. 30, Blakely, Scott county, W. R Salisbury's well was yellow till, 15 feet; blue till, 30 feet; and "mud, like a lake bottom," three feet, this lowest bed containing many shells, grass, and apparently grains of wild rice. In Hutchinson, 5 miles east of the village, the well at Nancy Nutt's, in S. E. ¼ of sec. 35, was upper till, 14 feet; much harder lower till, 16 feet; and gray sand, 2 feet, the last containing abundant snail-shells, like those now living in our lakes. S. D. Ross' well, ¼ mile east of this, was similar, finding at the bottom a bed of sand filled with these shells. At Olivia station, in sec. 7, Bird Island, Renville county, the well at Lincoln Brothers' mill was yellow till, picked, 10 feet; softer but more rocky blue till, 9 feet; very hard blue till, 1 foot; and quicksand, 4 feet. A log, apparently tamarack, 8 inches in diameter, with several smaller sticks and twigs, lay across this well, embedded in the top of the quicksand. They were chopped off at each side. G. W. Burch, 2 miles south-west from this, in sec. 24, Troy, found upper till, 18 feet; dry, yellow sand, 4 feet; soft blue till, 15 feet; black loam, perhaps an interglacial soil, 2 feet; and gray quicksand, 4 feet, its upper part containing a log and smaller sticks like the foregoing. Several other wells within one or two miles about Olivia show similar remains of a deeply buried tamarack swamp. At Barnesville, in Clay county, John Marth's well was till, 12 feet; then, quicksand, 1 foot, containing several sticks of tamarack up to 8 inches in diameter, lying across the well, which, together with the inflow of water, prevented farther digging. In the N. E. ¼ of sec. 28, t. 135, r. 47, Wilkin county, C. R. Gleason's well was upper till, 8 feet; gray sand, ½ inch; much harder lower till, 18 feet; underlain by sandy black mud, containing many snail-shells. The two last are within the area that was afterward covered by Lake Agassiz. All these wells found a supply of water in the beds containing the fossils and therefore stopped before reaching the till which almost certainly underlies them. The locality first mentioned, in Blakely, is just at the top of the bluffs of Minnesota river, so that the entire depth of the drift at this place, composed about wholly of till, is known to be more than three times that of the well. The drift is probably of equal thickness in the other places; and, as shown by numerous wells 125 to 265 feet deep, it is generally composed of till, enclosing occasional stratified beds. Two other instances in which shells were found by wells in till, at Stewart and near Campbell, but where nothing definite has yet been learned about them; shells found in the brick clay at Chaska overlain by till; and a tamarack swamp at Fergus Falls, buried under 12 feet of very coarse fluvial deposits, complete this list. Though these examples are few in number, they yet are regarded as undeniable evidence that animals and plants occupied the land during temperate interglacial epochs, preceded and followed by an arctic climate and ice-sheets like those now covering the interior of Greenland and the Antarctic continent. The occurrence of interglacial shells and trees in

the Red river valley appears to prove that the departure of the ice in their epoch was sufficient to allow the drainage of this valley northward.

If successive ice-sheets have thus been accumulated and pushed forward upon this area, some of them doubtless formed terminal moraines, which were afterward covered and their mounds and hills of coarsely rocky drift spread in a nearly level stratum by the more extended ice-sheet of a later epoch. Such a buried moraine is exposed by the deep channel of the upper Minnesota river. The till here is found to contain, at a depth of 40 or 50 feet below the general surface, a stratum that abounds in boulders, usually producing a narrow shelf or terrace upon the bluffs. About Correll station, in Big Stone county, this rocky layer in the till has caused an extensive plain to be left in the process of erosion, 50 feet below the top of the bluffs and about 75 feet above the river. It is everywhere plentifully strown with boulders, and in some portions these occur in heaps and patches covering half the ground. The deserted channels north-east of Lac qui Parle frequently have their bed upon this stratum of boulders. Its exposures along the Minnesota valley were seen in many places through a distance of 50 miles, extending from the Correll plain to a point three miles below the mouth of the Yellow Medicine river.

*Modified Drift.* In addition to the beds of modified drift enclosed in the till or lying below it, other accumulations deposited by water occur on the surface of areas which are mainly till. They consist of interstratified gravel and sand in knolls or mounds that rise 10 to 20 feet above the general level. These are seldom very numerous, and are rarely extended in ridges or in any noticeable series. Their origin, however, was probably similar to that of the gravel ridges or kames which often form long series in other drift regions, being the deposits of glacial rivers poured down from the surface of the melting ice-fields. The only place where kames of the usual type have been observed, occurring as well-marked parallel ridges of interbedded gravel and sand, is two miles south-east of Lake Johanna in Pope county. Here they are from 25 to 75 feet high, extending two miles from north to south, and the land at each side is modified drift. A less typical ridge of this kind forms the west shore of Wall lake, five miles east of Fergus Falls.

The lake deposits of the Red River valley have been partially described, and their origin treated of, in an earlier part of this report. A section of these beds at Glyndon, shown by a boring at the elevator of G. S. Barnes & Co., was soil, 3 feet; quicksand, 22 feet; dark clay, free from stones, 75 feet; very hard yellowish till, 15 feet; softer till, 10 feet. In Moorhead the well at John Erickson's brewery was light-colored clay, 20 feet; quicksand, 4 feet; blue clay, with gravel and boulders, 80 feet; underlain by sand from which water rose immediately about 80 feet. A. H. Moore's well at Fargo, within a mile west from the last, was similar, being yellow clay, 15 feet; sand, 3 feet; dark, bluish clay, 77 feet, free from pebbles, excepting in its last two feet; underlain by sand from which water rose to 7 feet below the surface. At Georgetown, 16 miles north from these, a well 80 feet deep was wholly in stratified clay, yellowish for about 10 feet at the top and dark bluish below, finding no sandy layers and no water.

The modified drift which covers the greater part of eastern Becker and Otter Tail counties is in contrast with this plain of lacustrine clay, being almost wholly sand and fine gravel, sometimes level, again moderately undulating,

and occasionally, as at Detroit, in swells and hills 25 to 40 feet high. These deposits are not often penetrated by wells, which show them to be in some places at least 80 feet deep. Southward, similar accumulations of sand and gravel are found in the east edge of Douglas and Pope counties, while eastward they have a large extent outside the limits of this report. They are believed to have been deposited by descending floods produced and freighted by a departing ice-sheet, which appears to have sloped toward this area from the west, north, and east.

Glacial melting also filled the great valleys with stratified gravel, sand and clay. Clearwater and Monticello prairies in Wright county are expansions of this glacial flood-plain of the Mississippi. Since the ice-age the river has channelled out and carried away much of these deposits, leaving remnants upon each side. At Monticello and Clearwater these plains of modified drift are 70 to 80 feet above the river. Between them and the bottomland, or flood-plain of the present time, an intermediate terrace is frequently seen. Monticello village is situated on such an area, about 35 feet above the river. Northward, at St. Cloud and Brainerd, the old flood-plain is about 60 feet high; to the southeast it descends a little faster than the river, its height being 45 feet at Dayton, and from 25 to 30 at the head of St. Anthony's falls.

The valley of the Minnesota river from Mankato to its mouth was also filled with modified drift. Its remnants include a terrace 3 miles long east and south of Kasota; the "sand prairie" about 4 miles long and averaging a mile wide, west and north of St. Peter; Le Sueur prairie, 6 miles long and from 1 to 3 miles wide, beginning east of Ottawa and reaching to Le Sueur; the plain 5 miles long and a mile wide, near the middle of which Belle Plaine is built; Spirit hill and "sand prairie," south-west and north-west of Jordan; a terrace 8 miles long and varying from a few rods to 2 miles in width, extending through San Francisco, Dahlgren, and Carver; and Shakopee prairie, 8 miles long and averaging one mile wide. The height of these plains at Kasota, St. Peter, and Le Sueur, is about 150 feet above the river; at Belle Plaine, about 135; and at Jordan, Carver, and Shakopee, about 125. Wells on the "sand prairie" near St. Peter and on Le Sueur prairie go through sand and gravel, sometimes with layers of clay, to the depth of 75 or 100 feet, finding till below. At Belle Plaine the sand and gravel are about 50 feet deep, underlain by till. Shakopee prairie has 40 or 50 feet of this modified drift, lying upon limestone. The principal remnant of these deposits seen below Shakopee was a terrace about 75 feet high, ⅛ to ⅓ mile wide, and 4 miles long, extending through Eagan in Dakota county, its north end being about 2 miles south of Fort Snelling. This valley was first excavated in till, which rises in continuous bluffs on each side 50 to 100 feet above these high plains and terraces of modified drift. It was afterward filled for 60 miles next to its mouth with fluvial deposits 75 to 150 feet thick, sloping about 2 feet per mile, through which the channel has been cut anew. Above Mankato the valley rarely shows any similar remnants of modified drift; and those which are found appear to have been part of local accumulations, rather than of a continuous flood-plain. Further remarks relating to the orgin of the modified drift in this valley are to be found in the description, under the ensuing division of this report, of the brick clays at Chaska, Carver, and Jordan.

ECONOMIC GEOLOGY.

The chief contributions to the wealth of Minnesota, derived directly from geological formations in this district, are bricks, lime, and quarried stone. Explorations made for coal, its mode of occurrence, and the improbability that it exists here in any valuable amount, have been spoken of in our account of the cretaceous strata. No ores of any practical importance have been found. The principal resources of this part of the State are the products of its invariably fertile soil, and the water-powers afforded by many of its streams, which, by using their lakes for reservoirs, may be made nearly uniform in flow throughout the year.

*Bricks.* Notes respecting the manufacture of bricks have been gathered wherever this work is done, and part of these are here presented. The material employed is usually stratified clay, belonging to the modified drift; sometimes along Minnesota River it is the alluvium now being deposited at every season of high water; and rarely, as at Fergus Falls, the clay used in brick-making appears to be a true till, in which portions quite free from gravel can be selected. The bricks made from the recent alluvial clay are red, but nearly all others throughout this region are cream-colored, this difference being due to the state of chemical combination assumed during the process of burning by the iron which these clays contain.

The following statements show the extent of this industry in the Valley of Minnesota River, where bricks are made at many places, among which Chaska leads with a yearly product of about seven millions. The order is that found in ascending the river.

At Shakopee, Schrœder Brothers have made bricks 4 years; annual product, 700,000, selling at $5 per M. Alluvial clay is used, with admixture of one part sand to two of clay.

At Chaska four companies are engaged in this business, all upon an area about an eighth of a mile in extent. This clay is modified drift of interglacial age. It varies from 20 to 40 feet in thickness, being underlain by sand and covered by till from 2 to 6 feet thick, holding boulders of all sizes up to 5 or 6 feet in diameter, many of which are planed and striated. This till forms the surface, 25 to 30 feet above the river. The only fossils found here were fresh-water mussel shells, which occurred in considerable numbers upon a space four rods in diameter near the middle of Gregg & Griswold's excavation, lying in the upper foot of the clay, just beneath the till. Brick-making was begun here twelve years ago, and has been steadily increasing to the present time. The first yard worked has been now owned by Gregg & Griswold six years. Their yearly product is about 2500 thousand, selling at $5 to $6 per M. From 40 to 50 men are employed for six months. Sand is mixed in varying proportions according to the quality of the clay, the average being about one part in ten. This company have machinery and room to make 40 thousand bricks daily. L. Warner makes about two millions yearly, employing 30 men. The proportion of sand used is from one-fourth to one-seventh. Wiest & Kruze make 1500 thousand yearly, having 20 men. The two last yards have been operated about 8 years. Schlafle, Strobach & Streissguth began three years ago, and in 1878 made 900 thousand; during 1879, they expected to make three millions, employing 40 men.

At Carver the clay used occurs 50 to 90 feet above the river, as a stratum from 30 to 40 feet thick, overlain and underlain by sand, being included in the modified drift which formerly filled this part of the valley. It probably was deposited during the retreat of the ice-sheet which overspread this region, as shown by the interglacial clay at Chaska, after the valley had been excavated between its bluffs of till. J. M. Nye & Co. here make 300 to 500 thousand bricks yearly; and Andrew Ahlin, about two-thirds of a mile southwest from Carver, has two yards, his annual product being from one to one and a half millions.

At Jordan Charles Rodell has made bricks 12 years, averaging about 500 thousand yearly, and selling at $6 per M. This clay deposit, as at Carver, is part of the stratified valley drift. It is 40 feet thick, lying upon till, and overlain by gravel and sand. The top of the clay is about 65 feet above the river. A very interesting kind of stratification is shown by this clay, which is bedded in distinct horizontal layers from 3 to 8 inches thick, averaging 6 inches. These layers are dark bluish, often finely laminated, changing above and below to a nearly black, more unctuous and finer clay, which forms the partings between them. These divisions are clearly seen through the whole extent of Mr. Rodell's excavation, which reaches 25 feet below the top of the clay and is 4 rods long. The same stratification is shown also by the excavation of Nye & Co. at Carver, where the exposure is 4 rods long and 15 feet high, except that here the layers all have a nearly uniform thickness of 3 inches. In this depth of 15 feet there are thus about sixty layers, all exactly alike. The alternating conditions which produced them were evidently repeated sixty times in uninterrupted succession. The only explanation for this which seems possible is that these divisions mark so many years occupied by the deposition of this clay. It appears that these clay-beds are of limited extent. The broad flood-plain was mainly built up by additions of fine gravel and sand spread over its surface by floods like those which now occasionally overflow the bottom-lands. Clay could settle only where hollows were formed by inequalities in this deposition and left outside the path of the principal current. Now nearly all the features of the modified drift, as the general absence of shells or other fossils, its hillocks and ridges called kames, and its occurrence only in glaciated regions or in valleys of drainage from them, indicate that this formation was accumulated by streams discharged from a melting ice-sheet. If the origin of the modified drift that filled the lower part of the Minnesota Valley was from such glacial melting, it is apparent that the floods would be greater and would bring and deposit more sediment in summer than in winter. Layers nearly like those in the clay at Carver and Jordan are also seen in other clay-beds in this valley and in that of the Mississippi in this State. The principal mass of each layer is regarded as the deposition during the warm portion of a year, and the very dark partings as the sediment during winter when the melting was less and the water consequently less turbid. The upper part of these beds of clay are generally colored yellow to a depth varying from one or two to ten feet, the lower portion being blue. The limit of the yellow color in the clay at Jordan runs obliquely, being nearly parallel with the sloping surface, so that the same horizontal layers are partly blue and partly yellow, which shows that this is a discoloration by weathering.

At Belle Plaine, Jacob Kranz has made bricks 10 years; annual product,

300 thousand, selling at $5 to $6 per M. The clay used is recent alluvium of the river, with which he mixes one-sixth as much sand as clay.

At Henderson bricks are made by Herman Matthei, who began 9 years ago, and now averages 400 thousand yearly; and by John Meier, who began in 1878, and expected to make 300 thousand during last season. Both use recent alluvium.

At LeSueur Henry Kruze has made bricks 16 years, using alluvial clay; annual product, 300 thousand. He mixes one part of sand with two of clay. J. Wetter also has made bricks here 8 years, averaging 100 thousand per year. His clay has a thickness of 5 feet, and is underlain by sand, the two forming a terrace about 100 feet above the river.

In Oshawa, about one mile south-west from St. Peter, Matthias Davidson has made bricks 19 years, using the recent alluvium. He averages 400 thousand yearly, and sells at $4 to $7 per M.

The brick-making at Mankato and New Ulm cannot be here reported. At Redwood Falls two kilns of brick, about 200 thousand, were burned by Bohn & Lamberton in 1878. The clay is about 40 feet above the top of the succession of falls here in Redwood river, and about 180 feet above Minnesota river. The section is black soil, 2 feet; yellow clay, dipping slightly eastward, about 7 feet; changing below to yellowish sand. This clay is in layers, mostly about 8 inches thick, divided by dark partings similar to those described at Carver and Jordan. The underlying sand is in layers from ¼ to 1 inch thick, separated by hard films of iron-rust. Attempts to make bricks at Minnesota Falls and Granite Falls have failed, because of small limy concretions in the clay, causing them to crack in burning. Bricks in this region command $8 per M.

At Montevideo, Nils Swennungson has made bricks two years; annual product, 60 thousand, selling at $6 to $10 per M. This clay is on the general level of the upland, 100 feet above the river. The section is soil, 1½ feet; yellow clay, used for brick-making, 3 feet; clayey sand, 6 inches; with clay containing limy concretions below.

At Big Stone City in Dakota, opposite Ortonville, Tobias Oehler began brick-making this year (1879). The clay is nearly like that of Montevideo. During this season he made 240 thousand, selling at $12 per M.

Brief notes of this production in counties north of the Minnesota river are the following, arranged in their order from south-east to north-west: ½ mile west of Dayton, in Otsego, Wright county, by Medor Arseno, about 250 M. yearly, at $7 to $8 per M.; at Cokato, Wright county, by James Runions, 300 M. yearly, for six years, at $8, the clay now nearly exhausted; 2 miles north of Hutchinson, McLeod county, by W. H. Wyman, 100 M. yearly, at $7 to $8; 3 miles north-east from Litchfield, Meeker county, by Henry Ames, 500 M. yearly at $7; at the north-west side of Nest lake in New London, Kandiyohi county, by Peter Larson, Jr., 200 to 300 M. yearly, at $8 to $10; at DeGraff, Swift county, 300 M. were made in 1877, selling at $10 per M.; at Glenwood, Pope county, by John Aiton, 150 to 300 M. yearly, at $7 to $10; 1½ miles north-east of Alexandria, Douglas county, by John A. McKay, 500 M. yearly, at $6 to $10; 3 miles south-west of Alexandria, in sec. 2, Lake Mary township, by Mark Bundy, 75 M. yearly; ½ mile north-west of Evansville station, Douglas county, by Richard Partridge, about 40 M. yearly at $10; about 3 miles west of Parker's Prairie, Otter Tail county,

by Henry Asseln, 100 M. in 1878, at $7 to $10; at Fergus Falls, by J. A. Nelson & Brothers, 100 M. formerly, 600 M. this year (1879), at about $8; 3 miles west of Fergus Falls, by S. R. Childs, 150 M. this year; at Detroit, Becker county, by Shaw & Martin, about 200 M. yearly at $8; and at Moorhead, by Lamb Brothers, 2500 M. yearly, at $6, and by Kruegel & Truitt, 1200 M. yearly. Additional details respecting this work and these and other deposits of clay adapted for brick-making, will be given in the final report.

*Lime.* The abundance or frequent occurrence of boulders and pebbles of magnesian limestone in the drift of this entire district, has been mentioned in describing that formation. The same stone, more finely pulverized, is one of the most important ingredients of our sand and clay also, being a principal cause of the great fertility of the soil throughout all these counties. A large part of the lime used for building, except along or near the lower Minnesota river, has been derived from the drift, its limestone boulders being gathered upon rocky, morainic areas, or about shallow lakes, where the expansion of the ice in winters has slowly pushed these and other rock-fragments outward to the shore. A little ridge of gravel and boulders is thus frequently heaped to a height varying from four to eight feet above the lake. In nearly every county several of the early settlers have availed themselves of this resource, constructing small kilns and burning from 50 to 200 barrels of lime yearly, according to the demand in their vicinity. This lime is usually of excellent quality, contains little sand, and is white, or sometimes cream-colored. We have a large list of these lime-burners, but can mention here only those who do a permanent and considerable business, as follow: at Dayton, Levi Guier, burning about 500 barrels of lime yearly, sold at $1 per barrel; in Greenleaf, Meeker county, Lewis Maher, from 100 to 300 barrels yearly, at $1.50; near Beaver Falls, Renville county, John Edget, R. R Corey, and several others, each about 100 barrels yearly, at $1.50; at Minnesota Falls, Simon Christianson and W. C. Darby, each 300 barrels yearly, at $1.50; one mile north of Ortonville, Alfred Knowlton, 500 barrels this year at $1.25; farther north-west, beside Big Stone lake, Jacob Hurley, E. T. Hanes, and William H. Bowman, selling yearly from 150 to 300 barrels each, at $1.25; at Donnelly, Stevens county, Joseph Meier, 300 to 400 barrels yearly, at $1.25; in Evansville, Douglas county, Partridge Brothers, 250 barrels yearly, at $1.25; in Leaf Mountain and Clitherall, Otter Tail county, Orris Albertson and others, 200 barrels or more yearly, at $1.25; at Fergus Falls, J. A. Nelson & Brothers, and E. Barbeau, each about 500 barrels yearly, at $1; in south part of Oscar, Otter Tail county, Peter Carlson, about 400 barrels yearly, at $1; in Eglon, Clay county, Nils Larson, from 75 to 250 barrels yearly, at $1; and at Detroit and White Earth Agency, Becker county, Shaw& Martin, 500 barrels yearly, at $1.50.

Limestone in fragments and pulverized is so large an ingredient of the drift that all percolating waters become more or less charged with carbonate of lime in solution. The soft rain-water is thus changed to hard water before it finds its way into wells or issues in springs. The limestone which the water has taken up forms a scale on the inside of tea-kettles and the boilers of engines; and similarly, because of exposure to the open air and evaporation, it is occasionally deposited by springs as an incrustation of moss, leaves, or other objects, or as a porous bed upon the surface of springy

ground. Interesting springs of this kind occur near Carver, Glenwood, and Big Stone City. Their calcareous deposit is commonly called "petrified moss," from the fact that it becomes covered with growing moss, the lower part of which is being slowly encrusted and its form preserved by this accumulation. It is usually a light gray, very porous mass, less than a foot thick, and mixed with earth and foreign matter; but in two places more massive deposits of this origin are found, which appear to have a value for the manufacture of lime. One of these, occurring in the N. E. ¼ of sec 26 and south part of sec. 23, Tunsburg, Chippewa county, has been considerably burned for lime by E. R. Harkness, who states that it yields a nearly pure, white lime, fully as strong as that of boulders. It here forms a nearly level layer 2 to 3 feet thick, extending fully a half mile as shown by frequent exposures upon the side of the bluff of till north-east of the Chippewa river. Only its south-east portion is adapted for lime-burning, the rest being gravelly. It appears to mark a line at which springs issued because of impervious beds above or below it. These springs are now partly intercepted by a tributary ravine 30 rods north-east, in which "petrified moss" is forming along a distance of about an eighth of a mile, at a height of three to six feet above the rill. About twenty-five miles south-east from this, in the N. W. ¼ of section 22, south township of Hawk Creek, Renville county, a nearly compact calcareous deposit, containing impressions of leaves and sticks, is exposed for six to eight feet vertically in two masses four rods apart, on the south side of a ravine about fifty feet deep. It was probably formed by springs when this ravine was first channelled out, shortly after the glacial period.

Cretaceous strata in the vicinity of New Ulm, and the Shakopee limstone in the lower Minnesota valley, yield the most important supplies of lime derived from this district. The only kiln burning Cretaceous limestone north of Minnesota river and therefore within the limit of this district, is John Heymann's, about a half mile north of Redstone. His yearly product is from 1,000 to 1,500 barrels, sold at $1 per barrel. The section is soil, 2 feet; drift gravel, 1½ feet; cavernous, nodular, gray limestone, 2 feet; green clay with layers of red, 2 feet; and limestone as above, 2 feet; said to be underlain by clays and shales. These beds form a terrace about 35 feet above the river. Other kilns burning lime from this formation are situated on the opposite side of the river. This lime is strong and sets quickly, making a white plaster; except that it commonly includes a little clay, it is quite pure, having no magnesia or sand.

The Shakopee limestone gives a very dark lime, which slacks to a brown or cream color. It is magnesian, with a little admixture of sand, and is burned more easily, slacks with less heat, and sets more slowly, than pure lime. It is preferred by masons for brick and stone work, and for plastering except the finishing coat. The following notes were gathered respecting the manufacture of lime from this formation. At Shakopee, J. B. Conter burns 15,000 barrels yearly, selling it at Saint Paul and Minneapolis for 55 cents per barrel of 200 pounds. The section here is limestone, obscurely and irregularly bedded, yielding leather-colored lime, 6 to 8 feet; a lighter-colored calcareous sandstone, divided in beds about 8 inches thick, somewhat used for building stone, 2 feet; limestone nearly as above, in irregular beds from a few inches to one foot thick, yielding a very dark, blackish lime, 12 feet.

The stratification is nearly level; but all the beds are more or less fractured, porous and cavernous, with different colors in the same layer a rod apart. The color throughout is buff of various shades approaching pink, yellow, and brown. The top of the quarry is about 50 feet above the river, and this formation extends below to the water's edge. Mr. Conter also burns about 15,000 barrels of lime yearly at a quarry 5 miles to the south-west in Louisville. This limestone is nearly like that at Shakopee. It is arenaceous, but shows no continuous layer of sandstone. At Ottawa, Charles Schwartz burns about 400 barrels of lime yearly for the demand in his vicinity, selling at 60 cents per barrel. At Caroline, in sec. 17, Kasota, Conrad Smith burns 6,000 barrels yearly, selling at 55 cents per barrel. A third of a mile south-east from the last, George C. Clapp has burned lime 20 years, averaging 2,000 barrels yearly, but has done nothing in this business during the last two years. The last three use only the upper 2 to 5 feet of the limestone terrace at these places. A large amount of lime is also burned from the Shakopee limestone in Mankato, which is not included in this report.

The St. Lawrence limestone in sec. 13, Jessenland, Sibley county, has been used for lime-burning by Herman Matthei, brick-maker at Henderson. Five kilns of small size were burned here last year, but the stone is now teamed to Henderson before burning. The lime brings 60 cents per barrel.

*Quarried Stone.* The formations which are quarried in the valley of Minnesota river for building stone, foundations, bridge masonry, or similar uses, are the quartzyte at Redstone, and the three members of the Lower Magnesian group. The granite and gneiss of the upper Minnesota valley have not yet been worked to any considerable extent, but will probably furnish valuable quarries for the general market when a demand is created by the more complete settlement and increasing wealth of that region. Cretaceous sandstone, as previously mentioned, has been quarried slightly for culverts and cellar-walls in Courtland, 8 and 11 miles south-east from New Ulm; but the business is now discontinued or very small.

In the quartzyte at Redstone quarries are owned by Francis Baasen, about 30 rods south-east from the railroad-bridge, who formerly quarried $200 worth of stone yearly, but none for three years past; William Winkelmann, a few rods farther east, quarrying only for his own use in building; Frederick Meierding, a little farther east, now selling $100 worth yearly, formerly about $400 yearly; Gottlieb Arndt, one-fifth mile north-east from last, with annual sales from $50 to $300; and Joseph Reinhart, close east of the last, selling little now, formerly $300 worth per year. Only rough stone of small dimension is obtained, bringing from $2 to $3 per cord.

Quarries in the limestone at St. Lawrence are owned by Abraham Bisson and Philip Corbel, both renting to others the privilege to quarry for 50 cents a cord. The stone is sold at $3 or $3.50 per cord, the first of these quarries supplying fifty cords yearly and the second about twenty cords yearly. The sales for stone work from the quarries in Faxon and Jessenland are still smaller. Of this limestone at Hebron, in the south part of Nicollet township, quarries are owned, in order from east to west, by Abel Keene, William J. Phillips, William H. Thurston, and Mrs. J. H. Dunham. Some of these are rented at 50 cents per cord. The stone is sold for $3 per cord, and the extent of sales at each quarry varies from $100 to $300 yearly. Judson, opposite to Hebron, has other small quarries in this formation.

The Jordan sandstone is quarried at Jordan by Frank Nicolin and Philip Kipp. It lies in beds from eight inches to two or three feet thick. Mr. Nicolin's flour-mill at this place, built of this stone, is 60 by 70 feet in area and 75 feet high, in six stories, having its walls 5 feet thick at the base and 20 inches at the top. Besides this structure, which was erected in 1878 and 1879, Mr. Nicolin's quarry has within three years supplied $2000 worth of stone, sold to the Minneapolis & St. Louis railroad for bridge masonry and to other purchasers. Mr. Kipp's quarry, opened this year, has supplied about $200 worth, at $3.75 per cord. Foss, Wells & Co. also quarried this stone to build their mill and elevator.

The limestone at Shakopee is too much seamed and fractured and too irregularly bedded for use as a building stone. In ascending the river, quarries where stone is obtained from this formation for building purposes are found in Louisville, Ottawa, St. Peter, Kasota, and Mankato, the two last places having the largest business. This work at Mankato we cannot report. Opposite to this city, in Belgrade, three quarries on the land of John Q. A. Marsh and brother are rented mostly to Dennis Sullivan and John Duffee, who pay 50 cents per cord, selling at about $2 per cord for rough stone. A little further west, Andrew M. Wiemar owns a quarry opened last year. He supplies dimension stone, rough or hammered. The rock of these quarries is evenly colored and compact, in thick beds, and can supply blocks 5 by 4 by 2 feet, or slabs 8 feet long. Details of the other places are given in the order mentioned.

In Louisville, Mrs. M. A. Spencer owns a quarry which has been worked 15 years, with annual sales from $200 to $950. This stone is in layers from 1 to 3 feet thick, hard and compact, except that small cavities sometimes occur in it. It has been used for much of the bridge masonry of Scott and Carver counties, including the railroad-bridges at Chaska and Carver.

At Ottawa quarries are owned by Levi Case, John R. Clark, Robert Todd, John S. Randall, Robert Winegar, and Kasper Mäder. The annual product is from 50 to 300 cords from each, sold at $1 to $2.50 per cord. The stone here is in layers from a few inches to one foot thick. It is sold mostly for use within 10 or 15 miles to wall cellars and wells, little being sent away on the cars.

At St. Peter the stone is thinly bedded as at Ottawa, except in the Asylum quarry, where it lies in massive beds 1 to 4 feet thick. This quarry has been worked principally for the Asylum buildings. The other quarries are owned or worked by Jacob Bauer, Hugh Brogan, Ubalt Drenttel, John Malgren, and Henry Miller. Their annual product is 50 to 200 cords each, selling at $1.50 to $3 per cord.

Kasota has the best quarries found in this limestone within our limits. It is in beds from 6 inches to 2½ feet thick, pinkish buff in color, uniform in its texture, easily cut into any desired form, and durable under exposure to the weather. The most extensive business here is that of Breen & Young, who lease from Stewart, Breckenridge & Butters. They employ 35 men and 3 teams at quarrying and loading upon the cars, the product in 1879 being worth $15,000 as rough stone; it is dressed after reaching their shops in Saint Paul and Minneapolis, which brings their sales per year to about $30,000. The largest stone ever shipped by them weighed 10 tons, its dimensions in feet being 14 by 8 by 1. Their quarry can supply blocks of

large size and 2 or 2½ feet thick; slabs, as for cemetery borders, 20 feet long; and flag-stones 10 or 12 feet square and eight inches thick. Examples of the stone from this quarry are the residence of H. J. Willing, of the firm of Field, Leiter & Co., in Chicago; the First Baptist Church in Saint Paul; trimmings of the High School Building in Minneapolis; and trimmings of the State Prison in Stillwater. The only other quarry at this place is owned by J. W. Babcock, whose yearly sales are from $5,000 to $10,000. He has used stone to cut up which formed an unbroken sheet 60 feet long. Examples from this quarry are the trimmings of Odd Fellows' Hall in Saint Paul, and of Plymouth Church in Minneapolis.

# VI.

# REPORT OF PROFESSOR C. W. HALL.

*Prof. N. H. Winchell, State Geologist:*

SIR:—The party of the Geological and Natural History Survey of the State, detailed by you to visit Lake Superior during the past summer, was ready for operations the latter part of July. The objects of this expedition were to make collections of the fauna of the Northeastern part of the State, to make some additions to the collection from its flora made by Mr. Juni one year ago, and to make some observations on the rocks and minerals occurring along certain portions of the coast.

In addition to the two persons composing the survey party, there were two others, Rev. C. M. Terry of Minneapolis, and Prof. G. Weitbrecht, of the St. Paul High School. The latter gentleman, teacher of natural history in the institution with which he is connected, accompanied us for the purpose of making collections of geological specimens, alcoholic, dried, and various dissections for his classroom work, and for the museum, of which the St. Paul Board of Education is now laying the foundation. Both gentlemen rendered material aid in performing the various duties of our camp life, and for a considerable share of the time they saved the expense of one extra man.

The constant interest manifested in our work in every way, and particularly by the part they were ever seeking to bear, and the heartiness with which they entered into the spirit of our out-door life, rendered their presence a source of pleasure to us.

We reached Duluth on the morning of July 26. There we made some purchases of supplies, hired a sail-boat for a month or more, and made such other arrangements as were necessary for the character of our work down the coast. We there learned that the winds for some days had been strong up the coast, practically preventing all small sail and row boats from going down the shore. This fact made us anxious to avoid, if possible, the probability of a long and toilsome trip. To be transported to our place of destination, which was Grand Marias, in the course of a few hours, thus passing over the intervening distance without a great waste of time in waiting for winds and waves, and to begin our work at once, since the season for collecting was already far advanced, were with us the chief desiderata. It was through the good offices of Dr. V. Smith, U. S. Collector at Duluth, that we were enabled to realize our wishes. A steamer was to start at noon on her regular trip around the north shore of the lake. The master, when assured of the character of the expedition, offered, so far as he consistently could,

to assist us on our way. We took passage for Prince Arthur's Landing, feeling that if the lake should become so rough as to prevent our leaving the steamer before we had reached the shelter of the group of islands off Pigeon Point, we should even then have saved more than half the distance to our point of destination. The steamer reached what was supposed to be the vicinity of Grand Marias at half-past 11 o'clock at night. As the vessel came to and lowered our boat with our camp equipment and ourselves to the water, a heavy swell was running, and every appearance indicated a southwest wind. Fortunately for us the threatened wind did not rise; still we had ample opportunity to become thoroughly tired rowing our heavily loaded boat. We reached the shore just as day was dawning, and found ourselves about one and one-half miles below Grand Marais.

With Monday morning we entered upon our labors. The work of arranging for our stay was slight, as the Messrs. Mayhe v placed at our disposal an unused building, in which was a stove, the property of the survey, left there last fall at the close of the field work of that season. We pitched our tents on the shingle beach, obtained a stock of supplies, and settled down to steady work.

Mr. Roberts, a student of the University, who accompanied me to assist in making the collections, occupied himself almost exclusively with collecting plants and birds. Of the former here at Grand Marais as elsewhere along the coast we found great numbers, but the range in species was rather narrow. Since the season for the majority of plants was past that of flowering, we did not collect so many specimens as we might have done and should have desired to do earlier in the season. One point of considerable interest could not be investigated, namely: how the flora of the lake basin proper is related to that of the interior drained by the numerous streams that come tumbling down over the escarpment of the bordering ridge of hills and emptying into the lake. The greatest distance towards the interior we reached was only eight or ten miles, and this in the valley of a single river, the Devil's Track; consequently nc generalizations could be drawn.

The list collected by Mr. Juni and published in last year's report,* and to which the list and observations submitted herewith are mainly supplementary, gives, with few exceptions, those plants found growing on the lake shore where the temperature averages several degrees lower during the growing months than it does inland, where the wind, cooled by the waters of the lake, does not reach. No great differences would be expected; stil enough would probably be seen to make a distinction clear with reference to the habits at least of a few species. It would perhaps be premature to designate any particular species which is found in the one locality that is debarred by climatic conditions from existing in the other; yet many might be mentioned which, flourishing along the lake shore, present only scattering representatives, if representatives have been found in the interior, so far as this latter territory has been explored by any party of the survey at present being prosecuted. It is confidently expected that these parties will find as they push into the country to the north and west of Superior and explore the shores and marshes of the hundreds of smaller lakes as yet almost or quite unknown to the white man, many species now not known to science. This additional question ought also to be answered by the more complete results

* Seventh Annual Report, 1878, p. 35, et seq.

of our botanical labors: in what particulars does this lake flora distinguish itself from that of the Mississippi valley only so short a distance away?

One in passing along the shore from Duluth to the easternmost point of Northern Minnesota, may be led to suppose that there is a gradual but sure change in the flora of the shore; that this change is noticeable in the species observed as well as in the size to which they attain. A moment's consideration, however, ought to dispel this wrong impression. In the first place the difference in position is not enough to change materially the characters of the vegetable and animal life of this district. The extremity of Pigeon Point lies near 89° 24′ west and 48° 1′ north, according to the International Boundary Survey charts. Duluth lies near 92° 5′ west, and 46° 47′ north, according to the chart ("Lake Superior No. 3") of the survey of the northern and northwestern lakes. These figures locate the former point about eighty-six miles further north and one hundred and twenty-four miles further east than the latter. It requires a much greater distance than this, where distance alone is considered, to produce any marked change either in the size or the character of species. What differences there are between these two localities one hundred and fifty-one miles apart, must be accounted for on other grounds than distance inland or distance from the equator.

Both points mentioned are situated on the same shore of the same body of water; this body of water is so large and deep as to exert an almost oceanic effect on the climate near its shores, such as imparting a certain moisture to the air and diminishing the liability to sudden changes in its temperature; the temperature is through each season quite equable and very low, and the face of the country stretching inland from Duluth and from Pigeon Point is essentially the same, broken and hilly.

Again, during the progress of the geological explorations occasional trips inland were made, and some of the highest summits along the immediate vicinity of the lake were reached. Wherever the hills are covered with a fair depth of soil, whether it be owing to a drift deposit or a level plat from which the slowly formed soil material could not be washed by the heavy rains or the melting snows, they are heavily timbered. And it is not alone in the number of trees and shrubs; rock maples, birches, tamaracks, pines, &c., are found of enormous size. Carlton's Peak, whose summit lies nine hundred twenty-seven (927) feet above the lake level seems to be the only exception. This mountain, whose summit is a huge mass of nearly pure feldspar, bore a very stunted vegetation,—the pines, white birches and mountain ash were very small, but still about as large as one could expect even in a much warmer climate with no more soil for a foothold than this bare rock afforded. One hundred feet below the summit trees and shrubs were as large and as vigorous as at the lake shore. Professor Agassiz with his party ascended Mount Cambridge on St. Ignace Island in 1848, and from observations and collections made at that time he concludes, "that even a thousand feet will introduce very slight differences in the vegetation of these regions. For, though Mount Cambridge is about a thousand feet above the level of the lake, its whole slope is covered with the same vegetation which occurs at the very level of the lake."*

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* Lake Superior: Its Physical Character, Vegetation, and Animals, etc. Louis Agassiz, p. 184.

This, then, seems to be the key to all the observable differences: as we go northeastwardly, the coast becomes somewhat changed by the action of those forces which have made it geologically what it is,—a series of igneous dikes and overflows, and of various upheavals of the sedimenary strata.

Towards Pigeon Point the soil becomes thinner, until there is no foothold for vegetation, except in the fissures of the rocks and in hollows filled with rock fragments and vegetable mold.

This, then, seems to be the key to all the observable differences: this peculiar rock conformation has acted both directly and indirectly on the vegetation of the region. Wherever the protruding dikes and other abrupt masses of rock have offered no resistance to the denudation of the hillsides by the flooding streams which are always periodical over tracts so liable as is this to violent storms in summer, and heavy beds of snow in winter, erosion and transportation have been constant. Ever since the early Silurian times, when these beds were probably formed, there has been little or no deposit of soil upon them, resulting from the slow chemical changes in the rocks and the physical disintegration accompanying and resulting from them. These chemical and physical changes, so unremittingly going on, furnish food material for the growing vegetation. And when the areas are vast the differences resulting from different lithological conditions are plainly apparent to one who studies the plants; but here in northeastern Minnesota they are insignificant. Yet vigor of growth depends on soil; when this cannot accumulate, trees must be of diminutive size, and the preponderance of vegetation must be shrubby and herbaceous, giving a general appearance of barrenness to the face of the country.*

In last year's report allusion was made by the State Geologist to the agricultural resources of Northeastern Minnesota.† Further observations and inquiries by this expedition tend to confirm the views therein expressed, so far as they relate to the agricultural capabilities of that part of the State lying immediately along the lake shore. The soil on the hillsides sloping towards the lake appears for the most part to be thin, and the even contour of the surface leads to the belief that were the forests cut away the earth would, in a few years, be carried down into the water by heavy showers, and thus leave a long and almost uninterrupted line of barren rocks from Duluth to Pigeon Point. But when the summits of this ridge skirting the lake are reached a beautiful country of gently rising hills, separated by spacious valleys, extends inland as far as the eye can reach. From the summit of Carlton's Peak, one of the highest points in the northern part of the State, a landscape of surpassing beauty lies before the beholder. The valley of the Temperance river, a considerable stream which flows past the base of this mountain and shoots into the lake from a narrow and remarkable gorge,‡ can be traced as it winds among the hills from many miles inland,

*The subject of "The Vegetation of the Northern Shores of Lake Superior" has been so ably and thoroughly discussed by Professor Agassiz in his intensely interesting work, *Lake Superior; its Physical Character, Vegetation and Animals compared with those of other and similar Regions—Boston: Gould, Kendall & Lincoln*, 1850, that no further discussion is necessary here.

†Seventh Annual Report, 1878, p. 25.

‡Owen's Geological Survey of Wisconsin, Iowa & Minnesota. Phila., Lippencott, Grambo & Co., 1852, pp. 378 and 379.

and the range can be seen, which probably lies beyond this long and narrow lake, in which both the Temperance and the Brulé are said to take their rise. From summits above Caribou Point, Terrace Point, and the mouth of the Devil's Track, as well as from the highest peaks in the Grand Portage Indian Reservation, landscapes of almost equal beauty and attractiveness can be seen.

Throughout the whole distance visited wherever openings have been cut and any attempts at crop raising have been made, excellent success has been met with. At Beaver Bay encouraging accounts were given by Mr. Christian Wieland of experiments made at that place in wheat-raising. From one piece of five acres of newly cleared land sown to wheat 28 bushels, 26 bushels and 23 bushels per acre was the yield for the first three years respectively; and the quality of the grain was excellent Other localities where wheat has been more thoroughly tried have given even more flattering results. The first premium at the State Fair in 1878 gave St. Louis county an enviable reputation among those lying in the winter wheat growing belt of the State. The successful exhibit, that of Mr. Jacob Zimmerman, showed a yield in 1878 of 54 bushels of winter wheat per acre, weighing 62 pounds per bushel, and was grown in sec. 28, township 50, range 15.*

The wooded and broken character of the country is often mentioned as highly favorable to the development of a wheat-producing region, as the danger of loss from wind-storms is thereby materially lessened. The proximity of the lake would have a tendency to keep the temperature low during the season when the wheat berry is forming and ripening; so it seems hardly possible that such a discouraging blight as swept over the southern part of the State in 1878 could ever afflict St. Louis and Lake counties. Oats and barley should by no means be omitted if one were to make out a list of those cereals whose successful cultivation here has been placed beyond a doubt.

Two hundred bushels of potatoes per acre is called a small yield. More than this, the potatoes are of the finest quality. It is claimed in Duluth that in the Chicago market the deliciousness of the Lake Superior potatoes is appreciated so highly as to make them preferred above those from any other locality in the West or Northwest.

But it seems after all as if this part of the State is to be a stock-raising rather than a cereal-producing territory. The peculiar character of the soil adapts it especially to grass, and without the least apparent difficulty the wild species give way to the cultivated. From one and a half to two tons per acre is the usual yield with scarcely any care, and there are many unusually fine meadows in the counties just named. The hillsides, when cleared of the timber now covering them, will afford unsurpassed pasturage, while countless springs and rivulets and larger streams will give a never-failing supply of the purest water,—a condition that must never be overlooked in locating a stock or dairy farm. Convenience to market is another advantage which is here possessed. Cheap transportation by way of the lakes to the great centers of the wholesale trade of the country can be relied on for seven or eight months of the year, and the provident farmer will make his sales to fit the season of prevailing high prices. Hay, live stock,

* From a Pamphlet issued by the St. Paul & Duluth R. R. Co., St. Paul, Minn., p. 32.

beef, butter, and all farm products can be transported to Chicago and New York as well as can wheat and oats and barley.

Along the hillsides sloping towards the lake, as well as along those lying further inland, there are many scattering pines. Occasionally a section is thickly studded with them. Their scattered occurrence renders these trees practically inaccessible, for the dense forests are impassable before much time has been taken to cut out a trail through the underbrush and the terrible windfalls. Only where many logs can be hauled over a single road can this expense be afforded; hence there are but few places along the shore where any attempts have been made to procure lumber, and those notably in the vicinity of Beaver Bay, and by the Wieland Brothers of that place. These gentlemen have constructed a mill which cuts annually a respectable quantity of timber. They employ about them mostly Indian help, thus settling, so far as their own locality is concerned, the much vexed Indian question. Several parties of pine explorers were met during the season who were searching for pine lands up the rivers along the shore. Every available section bearing pine in any quantity was selected. These explorations were made chiefly, it is believed, in the interests of Michigan dealers.* Private advices from Duluth state also that parties from that place are diligently exploring the whole valley of the St. Louis and its tributaries, and every available section that can be found is taken up, so that in a very short time there will be scarcely an acre of pine land on the market in northeastern Minnesota. Sections containing the scattering trees have no value as "pine lands." It is well known that the trees that stand isolated when of a size suitable for lumber are hollow, or so decayed at the heart that no good logs can be cut from them until the branches are nearly reached.

But more attention was paid to the collection of zoological than of botanical specimens. Mr. Roberts collected one hundred and twenty-five skins of birds,† which are now deposited in the University for study and identification of the species, illustration of varietal characters and for class-room demonstration. In addition to these skins a number of specimens were dissected out and prepared for future use. These specimens consisted of visceral parts, sterna, &c. A full list will find place in the catalogue of the general museum. A number of the sterna from the birds above mentioned have been mounted on pedestals by Mr. Herrick, and they will prove to be a very useful adjunct in studying the form characteristics of those birds from which they were taken, and for illustrating comparative anatomy.

The following are the sterna mentioned; the numbers correspond to the original number of the skins in Mr. Robert's collection, and those without numbers have been added to the list from Mr. Herrick's private collection:

27. Carolina Rail ............................ *Porzana carolina.*
40. Wild Pigeon ............................ *Ectopistes migratorius.*
46. Herring Gull ............................ *Larus argentatus.*
48. Pigeon Hawk ............................ *Falco columbarius.*
49. Black-billed Cuckoo ...................... *Coccygus erythrophthalmus.*

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* Some of these "explorers" were employed by English capitalists, the pine being intended for exportation at Quebec.—N. H. W.

†A full list of these skins with the collector's notes have been placed in the hands of the State Ornithologist for publication.

| | | |
|---|---|---|
| 74. | Red-winged Blackbird | *Aegeleus phoeniceus.* |
| 78. | Sparrow Hawk | *Falco sparverius* (2 spec's). |
| 80. | Ring-billed Gull | *Larus delawarensis.* |
| 81. | Broad-winged Hawk | *Buteo pennsylvanicus.* |
| 94. | Hairy Woodpecker | *Picus villosus.* |
| 96. | Great Horned Owl | *Bubo virginianus.* |
| 103. | Mallard Duck | *Anas boschas.* |
| 122. | Northern Phalerope | *Lobipes hyperboreus.* |
| 124. | Golden-winged Woodpecker | *Colaptes auratus.* |
| 125. | Spotted Sandpiper | *Tringoides macularius.* |
| 126. | Night Hawk | *Chordeiles popetue.* |
| 127. | Crow | *Corvus americanus.* |
| | Chimney Swallow | *Chætura pelagica.* |
| | Red-headed Woodpecker | *Melanerpes erythrocephalus.* |
| | Night Hawk | *Chordeiles popetue.* |
| | Kingbird | *Tyrannus carolinensis.* |
| | Flicker | *Colaptes auratus.* |
| | American Bittern | *Botaurus lentiginosus.* |
| | Great Horned Owl | *Bubo virginianus.* |
| | Marsh Harrier | *Circus cyaneus.* |
| | Brown Thrush | *Harporhynchus rufus.* |
| | Spotted Sandpiper | *Tringoides macularius.* |

We hope to make constant additions to this nucleus of exceedingly interesting specimens, and in time to have a complete set from the birds of Minnesota. A hearty invitation is hereby extended to all who are collecting in this attractive field of ornithology to aid the General Museum in this direction. There is no place where that branch of anatomy can be studied with more interest and profit which discloses to us the principles of animal machanism and of animal locomotion.

The collections of insects made during the season were considerable, but with few exceptions they have not yet been fully identified and made ready for the museum.. The endeavor will be made during the coming season to arrange all that are of value to us in a manner suitable for use and exhibition.

Of the fishes of this region a fair supply was obtained. Many of the rarer species and those less valued as food fishes were not taken, since no special efforts were made to extend the collection to include what might be considered a series of those species living in the waters of the northern part of the State.

Some very fine specimens of the brook-trout, *Salmo fontinalis*, were obtained from the numerous streams of the region visited. The largest one brought home, a magnificent trout caught with a hook by Rev. C. M. Terry from the Devil's Track, and presented to the collection, measured over twenty-one inches in length, and must have weighed nearly five pounds. One larger brook-trout was seen during the trip. One morning an Indian brought one to our camp at Grand Marais which was over twenty-four inches long and weighed five and three-quarters pounds. It was caught in a gill net in the lake just off the rocky entrance to the harbor. As we had no jar in the museum large enough to hold a fish of this size, we regretted the

necessity that compelled us to make our breakfast that morning on brook trout.

And right here it is appropriate to say that if this survey have economic importance to the people of the State, it should be the effort of those engaged in its work to urge the preservation of what nature has given us in the shape of game, fish, forests, and scenery, as well as to point out the places where precious metals may be found, where fuel lies deposited, or where the finest building stones may be quarried.

The brook-trout is an object of wanton destruction in northeastern Minnesota. This beautiful and universally admired species inhabits, in great numbers, the many small rivers flowing into Superior. These streams, in fact, have become one of the most famous fishing grounds on the continent. That they may continue so, they must be protected. Those within the State of Minnesota are visited annually by large numbers of amateur fishermen, who go in parties, and thus make most enjoyable vacation excursions. A boatman and a cook are engaged at Duluth or some other accessible point, who load into a sail-boat a store of provisions and other essentials to comfort and pleasure, and then take the excursionists to the best trout streams around the lake. One stream after another is visited. A camp is pitched beside each where it empties into the lake. Then, for several days, perhaps a week, the river banks are lined with the creeping, stealthy forms of the fishermen, throwing every temptation the ingenuity of man can devise before the eyes of the wary trout. By diligently and patiently continuing at their posts through every hour from daylight until evening, it is surprising if any fish are spared in the stream. So far as the trout are caught and saved for food within the legal fishing season, it is not proposed here to find fault with the fishermen. The trout is one of those species of fish that breed during the autumn and early winter; so during the latter summer and the autumn months vast numbers are ascending the streams preparatory to selecting a suitable spot for a spawning ground. At this season the fish should be protected, that as large a number of eggs as possible may be deposited. But to catch trout at any season of the year solely for the fun of the fishing is an inhuman and wasteful sport that the State should forbid and punish for what it is—an offense against humanity, public morality, and the future well being of the commonwealth. No milder expression for stating the case can well be used, when a party of anglers fish a stream until every trout that can be captured by all the devices of modern skill and experience, has been brought to land, and then, after the day's catch has been counted, carelessly thrown away where its decay will infect the air or poison the water and thus prevent its being inhabited by others. Specific cases of this character can be mentioned where the waters of streams have been so poisoned in this manner that no fish have lived in them for two or three years. It is a very common thing for parties to fish out a stream and select only the very largest specimens for eating and salting, throwing all the rest, probably three-fourths of their whole number, back into the river. Such treatment of the fishing grounds causes much indignation among the people living in the northern part of the State, and who have a lively interest in the preservation of their fish and game. It is true we have game laws, but it is a very difficult thing to have them enforced so that all would hold a proper respect for them.

One other matter is worth bringing again to the attention of the people of this State.

Last year the State Geologist made protest* against the wholesale destruction of timber in the northeastern part of this State and across the boundary in Canada. A lawless set of "explorers," who own nothing and feel no responsibility, have within the past few years, destroyed more timber and burned down to the rock more of what could be made fine grazing land than probably all the gold and silver they will ever find can pay for. This frequent destruction, for it occurs every year of late, has been chiefly wanton, only occasionally are the fires the result of accident. Very often when an "explorer" finds a vein of quartz or calcite with a sprinkling of galenite or blende, crossing one of the river gorges so common in that part of the State, he takes, its direction and coolly proceeds to set fires along its course, that when the leaves and soil are burned off he may examine it in various places across the country, and, if there be a trace of any metal, proceed to mark out mining locations. The land is not his; the agent or the owner is a hundred or more miles away and can know nothing of the crime; while the party committing it has a possible chance of becoming rich from the fractional ownership in the spot which he receives from the speculator who furnishes him with his outfit. The northeastern part of Minnesota, together with the contiguous part of Canada, may develop into one of our finest mining regions,—in fact there are many geological indications of its exceeding richness in minerals, but the writer has no idea that its product from this source will ever approach the capability of this area considered as a well developed agricultural and grazing region.

Mining operations cannot be carried on successfully in this region for many years to come. The country is still a primeval wilderness. There are no inhabitants beyond the borders of the lake. There are no means of communication from one point to another, except by rough narrow trails and by canoes. The mining locations thus far taken possession of will average from thirty-five to forty-five miles from the lake shore. Mining supplies and provisions for the interior must be taken to the place of operations by troops of Indian packers, each one of whom takes a package of about one hundred pounds weight, which he transports in a canoe along the navigable water-courses and carries on his back suspended by a strap across his head whenever he leaves his canoe. In the winter season trains of dogs are brought into requisition, and these poor abused creatures would, if they only could, pray for death every hour of the day as a relief from their surfeit of starvation and the heartless cruelty of their treatment. Such is the usual mode of transportation; but where a settled business is established other and more civilized methods are adopted,—usually on the plan of each male member of the settlement doing a share of the work proportionate to his strength. The Mayhew brothers of Grand Marais each winter as soon as snow falls fit up their train consisting of a dog, a billy goat and a bull.

During the past season a road has been cut through the forest, along the shore of the lake from Duluth to Grand Marais. This road is a very primitive affair: the trees along its course have been cut down to the roots, old logs have been removed, knolls cut away and the streams spanned with

*Annual Report for the year 1878, p. 24.

corduroy bridges; in short, a broad trail has been opened chiefly for the dog trains that carry the Canadian mails during the period when navigation from Prince Arthur's Landing to Duluth is closed by the ice. This government trail will, no doubt, eventually develop into a substantial highway, as soon as there is a demand for its more thorough construction and constant repair. But the lake will always be used as the cheapest and readiest means of transit during those months of the year when navigation is open, and it will more and more be brought into use as the increasing demands of this large contiguous territory make more regular and frequent the trips of the various lines of boats and packets.

Another step looking towards the development of this lake Superior portion of the State, has been taken. It has long been deplored by those familiar with the northwest shore of the lake that there was throughout its whole distance, from Pigeon Point to Duluth, no shelter where the larger boats could find refuge from storms. The whole extent of this coast line is rocky: it has but two or three natural harbors, and is exceedingly liable to storms and heavy winds, especially in the autumn. An appropriation was made by the present Congress, at its first session, of ten thousand dollars, for dredging and otherwise improving Grand Marais harbor. This harbor is one of the most beautiful spots to be seen anywhere around the great lakes. The bay is nearly circular, about two miles in circumference, and entirely inclosed from the lake, excepting a natural entrance, about one thousand feet wide. The inner shore of the bay is composed of the characteristic brown shingle of the north shore, while along its front a wall of solid rock separates the inclosed water from the lake. The natural depth of the water reaches from fifteen to seventeen feet, but the area over which this depth is reached is not large enough to admit the handling of large vessels within the bay. The improvements of Grand Marais harbor have been begun under a United States engineer, Major Allen, of St. Paul, who will make it ready to meet the necessities of the navigation of this part of lake Superior, just as fast as the U. S. government will appropriate money for carrying on the work.

The foregoing remarks have been written in the endeavor to point out the present and immediately prospective condition of the mining and other industries in this part of the State, and to show the absolute lack, so far as the needs of the mining interests are concerned, of the shadow of an excuse for the wholesale destruction of forests which there annually occurs.

The suggestion of the State Geologist, expressed last year, is most heartily seconded that some action be taken, either in concert with the Canadian authorities or by this State alone, towards repressing this destruction. If no other way be sufficient, it would well pay to employ officers to ferret out violations of law and to bring offenders to punishment.

So far as the geological and mineralogical work is concerned there is but little to report at this time. The observations made were limited, for the most part, to a strip of coast lying between the mouth of Poplar River and that of the Devil's Track. This section is about twenty-five miles long. It is, like all the rest of the distance from Duluth to Pigeon Point, rocky and often precipitous. The rock strata, almost entirely dark-colored basic, and of igneous origin, belong evidently to the so-called cupriferous series of the Lake Superior system; the only exceptions so far as noticed were,

according to present recollection, an outcrop of quartzytic conglomerate below Poplar River, a bed of sandstone varying not far from one hundred feet in thickness, sandwiched in between two beds of the igneous rock at Good Harbor Bay, and several outcrops of shale in the neighborhood of Grand Marais. This latter rock, even when not in sight along the shore, discloses its presence under the water or underneath the drift or lacustrine deposits above the beach by the shingle beaches it makes. Its color is a prevailing reddish brown, and it is very generally highly fractured; indeed, in the vicinity of the dikes, which frequently break through it, the beds are literally shivered into fine fragments.

These pieces are easily broken away by the combined action of the frost and waves, and the ceaseless movement of the water wears them to a smooth and uniformly flattened form, induced by the distances between the jointed surfaces. The hardness of the rock is very uniform, consequently the "shingle" is composed of pebbles of constant size and very regular outlines.

So far as can be judged from three or four thin sections, hastily examined, the igneous rock is a diabase. Essentially the same rock is found below Duluth, and the microscopical characters show but little variation throughout the whole coast-line wherever this modification appears—no more than would naturally be expected, perhaps, in extending the observations of a single series over so large an extent of territory as the northern border of this Lake Superior basin comprises.

A section of the rock at Good Harbor bay shows a triclinic feldspar and augite as the two most abundant constituents, together with some granules of ferric oxide and magnetic iron. In the freshest parts the bed shows no extended decomposition. The feldspar seems to have been developed first, since it shows long, slender crystals lying in all directions through the rock. For the most part the crystals are so small that they show only two lamellæ, thus reminding one of Carlsbad twins so clearly shown in some orthoclase or monoclinic crystals of feldspar. There are, however, many larger porphyritic crystals of feldspar which show undoubted triclinic striations, and contain numerous inclusions,—rectangular, spherical, and of every imaginable form and appearance. The augite is granular for the most part, though there are some clearly defined crystal outlines. On the whole, it seems to fill the interstices between the feldspar crystals wherever there is space to occupy, yielding but very little to the other constituent and the various accessory minerals. Toward the top of the beds decomposition has greatly changed the outward appearance, and has produced a corresponding change in the mineral constitution of the rock. Resulting from the decomposition and disintegration of these primary constituents are many secondary products of various chemical constitution and physical characters. The two most commonly occurring secondary minerals in diabasic rocks are ferric oxide and chlorite, or some green mineral of substantially the same general properties. In this particular locality the minerals resulting from this decomposition are unique and interesting. The most interesting one, perhaps, to the mineralogist, is the Thomsonite,* with Lintonite as a modification; but it is a modification possessing such marked characters that, in the opinion of Professor C. N. Shepard, as expressed in a private letter to Pro-

* See the American Journal of Science and Arts for February, 1880, article Lintonite and other forms of Thomsonite, by S. F. Peckham and C. W. Hall.

fessor Peckham, it will hold its place as a distinct species. These minerals do not occur in every part of these diabasic beds, but only in those parts that seem to be the upper and porous layers of the overflow. Their habitus is quite nnmistakably amygdaloidal, and in size they reach as high as three inches in diameter.

In addition to the observations, here only outlined, which were made along the shore, trips were also made to the summits of several of the series of elevations composing the Sawteeth Mountains, a range extending from Carlton's Peak down the coast to the Devil's Track and beyond.

These elevations are formed by the combined result of igneous action, foldings of the sedimentary strata and erosion. The beds have a general southerly dip. As they rise from the lake at an angle varying from eight to twelve degrees, they reach a height of 600 or 800 feet and even more at a short distance from the shore, since the latter's course is southwest and northeast. On reaching the above mentioned height the summits break off in perpendicular precipices, one hundred or two hundred feet in height, banked up at the bottom with huge taluses of broken fragments of the fallen rock. Invariably at the foot of such a precipice there runs a stream generally of considerable size, which discloses in the outcrops along its bed the general character of the lower layers of the rock. The rock which forms these summits seems to be substantially the same as the shore line diabase, &c.; and, indeed, in some places the continuous bedding can be traced, with but little interruption, from the summit almost to the shore; this is the case at Black Point, where a stream called Indian Camp river, courses along under the talus of Black Point Mountain, and finds its way down to the lake over a continuously rocky bed until it reaches almost the water's level. The rock at the top of this peak is highly porphyritic, and also carries many thomsonites. In the bed of the stream just named, near one hundred and fifty feet below the summit, the rock is very compact and carries but few thomsonites and occasional feldspar crystals. These latter attain a length of two inches or more and are filled with inclusions that impart a peculiar greenish tinge to their color.

It has already been stated that the rock constituting the summit of Carlton's Peak is a nearly pure feldspar. This rock is very coarsely granular, —the grains often showing a cleavage surface of half an inch or more across. Without being more definite it can be stated the feldspar is a variety of the triclinic group. The summits of other peaks consist of a porphyry of which, in many hand specimens at least, seventy per cent. of the mass is composed of large crystals of triclinic feldspar; while the rock along the shore is fine in texture and presents only occasional crystals of this mineral.

So the question very naturally arises in the mind of the observer,—Are not these three types mere steps in the modification of one and the same rock species? And he will at once set to work to trace out the probabilities and the possibilities in the case. Indeed, so long as the continuity of the bedding cannot easily be followed from the fresh massive rock at Good Harbor bay to the typical feldspar of Carlton's Peak, many facts seem to favor the acceptance of the theory that a sufficient change has been effected through the slow action of those chemical and physical forces ever accom-

plishing metamorphism to bring about all the differences to be seen in the specimens collected consecutively between these two extreme points.

Yet there are some objections to swallowing this theory wholly without mastication. The first one is suggested by the lithological structure of Carlton's Peak itself;* another may occur to one while observing the huge blocks of feldspar imbedded in what Dr. Norwood calls basalt,† at several places along the shore below the mouth of Split Rock river; still another objection is suspected to lie in the composition and nature of the feldspar itself. Only a careful study in the field and in the laboratory will settle the question.

The list of plants herewith reported comprises all those which were found and of which specimens were secured. There are upwards of one hundred additional to those reported by Mr. Juni, last year. Some of them seem to be the same as are contained in that collection, but under another name. It was thought best, therefore, to include all in this list and leave all corrections to the expert who shall hereafter, from the plants on hand, make a corrected list for final publication.

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# PLANTS OF THE NORTH SHORE OF LAKE SUPERIOR, MINNESOTA.

COLLECTED BY THOS. S. ROBERTS.

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The area embraced by the following list is a narrow strip of country along the north shore of Lake Superior from Duluth to the mouth of the Devil's Track River, forming the greater part of the lake front of St. Louis and Lake counties, Minn. The period of observation was from July 26 until Sept. 2, 1879.

The botany of the same region was reported upon by Mr. B. Juni, in the report for 1878; but as considerable new matter was obtained the past summer it has been thought best to present the full list of the species identified the present season with brief notes on their occurrence.

In the introduction to the report on Ornithology will be found a short description of the general character of the country worked over, so that it is not necessary to repeat it here. The vicinity of Duluth was examined very little, or no doubt many other introduced and marsh plants would have been found. As the party landed only here and there along the shore, and with the exception of two or three places but for a brief stay, it is not possible to give the general distribution of but a few species, and those the most noticeable ones. In other cases the locality where the species was found and its abundance there is all that can be given with any degree of certainty.

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* Owens' Geological Survey of Wisconsin, Iowa and Minnesota, Norwood's Report, p. 380.

† The same, p. 360, et seq.

The species marked with an asterisk (*) are in addition to Mr. Juni's list.

RANUNCULACEÆ. Crowfoot Family.

1. Clematis Virginiana, *L.* Common Virgin's Bower.—Occasional. Summit of Black Point Mountain and at Beaver Bay. In fruit Aug. 24.

2. Thalictrum Cornuti, *L.* Tall Meadow-Rue.—Common.

*3. Ranunculus abortivus, *L.* Small-flowered C.—Black Point. Fruit Aug. 24.

4. Ranunculus Pennsylvanicus, *L.* Bristly C.—Common everywhere.

5. Caltha palustris, *L.* Marsh Marigold.—Common.

*6. Coptis trifolia, *Salisb.* Three-leaved Goldthread.—Abundant, especially along Devil's Track River. In fruit Aug. 15.

7. Aquilegia Canadensis, *L,* Wild Columbine.—Grand Marais.

8. Actaea spicata, *L.*, var. rubra, *Michx.* Red Baneberry.—Common.

*9. Actaea alba. *Bigel.* White Baneberry.—Common. This and the preceding fruiting in August.

NYMPHAEACEÆ. Water-Lily Family.

10. Nuphar advena, *Ait.* Common Yellow Pond-lily.—Common in suitable places as in the pond at Grand Marais.

*11. Nuphar luteum, *Smith,* var pumilum. Small Yellow Pond-lily.—Found quite common and in bloom in Duluth Harbor July, 1877.

FUMARIACEÆ. Fumitory Family.

13. Corydalis glauca, *Pursh.* Pale Corydalis—Common and in full bloom, Aug. 25, on the nearly bald summit of Carlton Peak.—Grand Marais.

14. Corydalis aurea, *Willd.* Golden Corydalis.—Duluth, July, 1877.

CRUCIFERÆ. Mustard Family.

*15. Capsella Bursa-pastoris, *Moench.* Shepherd's Purse.—Abundant.

VIOLACEÆ. Violet Family.

*16. Viola rotundifolia, *Michx.* Round-leaved Violet. A violet, apparently this species, bearing so late in the season only cleistogamic flowers and fruit was common in the forest.

DROSERACEÆ. Sundew Family.

17. Drosera rotundifolia, *L.* Round-leaved Sundew.—Common in the marsh at Grand Marais and in a like situation on Minnesota Point.

HYPERICACEÆ. St. John's-wort Family.

*18. Hypericum mutilum, *L.* St. John's-wort.—Common near Stuart river, where it closely approaches var, *Gymnanthum.* Beaver Bay.

*19. Elodes Virginica, *Nutt.* Marsh St. John's-wort. Common; in fruit latter part of Aug. in marshes at Duluth and near Stewart river.

### CARYOPHYLLACEÆ. Pink Family.

*20. Cerastium viscosum, *L.* Larger Mouse-ear Chickweed.—Beaver Bay and Duluth; common. Is apparently this species and not *nutans, Raf.*

*21. Lychnis Githago, *Lam.* Corn Cockle.—Duluth.

### GERANIACEÆ. Geranium Family.

22. Geranium Carolinianum, *L.* Carolina Cranesbill.—Little Marais.

23. Impatiens fulva, *Nutt.* Spotted Touch-me-not.—Common everywhere. At Beaver Bay a spotless variety, with less reflected spur, was common and grew intermingled with the ordinary form, without showing any signs of intergradation.

*24. Oxalis Acetosella, *L.* Common Wood-sorrel.—Common in the deep Arbor-vitæ swamps. In this species each petal has a yellow spot at the base inside.

*25. Oxalis stricta, *L.* Yellow wood-sorrel.—Common at Beaver Bay. Duluth.

### ANACARDIACEÆ. Cashew Family.

26. Rhus Toxicodendron, *L.* Poison Ivy.—Minnesota Point; common.

### SAPINDACEÆ. Soapberry Family.

27. Acer spicatum, *Lam.* Mountain Maple.—Abundant all through the woods, and in fruit in August.

28. Acer saccharinum, *Wang.* Sugar Maple.—"Sugar bushes" are common, and a large amount of maple sugar is made by the Indians.

### LEGUMINOSÆ. Pulse Family.

*29. Trifolium pretense, *L.* Red Clover.—About towns. Common at Beaver Bay and Duluth; scarce at Grand Marais.

*30. Trifolium repens, *L.* White Clover.—Common.

31. Lathyrus maritimus, *Bigelow.* Beach Pea.—In addition to the three localities given by Mr. Juni this pea also occurs commonly at Beaver Bay and Sandy Beach; and doubtless at numerous other points along the shore. In the two localities just mentioned it was in bloom sparingly in the latter part of August, while a few plants were in fruit at Poplar River Aug. 6. It does not seem to be very faithful.

### ROSACEÆ. Rose Family.

32. Prunus Pennsylvanica, *L.* Wild Red Cherry.—Fruit ripe in latter part of August.

33. Spiræa opulifolia, *L.* Nine-Bark.—Common on the rocks all along the shore, where it was covered with bloom and fruit in the latter part of July and August.

34. Spiræa salicifolia, *L.* Meadow Sweet.—Common on the "peninsula" at Grand Marais.

*35. Geum macrophyllum, *Willd.* Avens.—Abundant.

36. Geum strictum, Ait. Avens. Grand Marais; in fruit July 31.

37. Potentilla Norvegica, *L.* Cinque-foil.—Common.

38. Potentilla fruticosa, *L.* Shrubby Cinque-foil. Abundant. Growing everywhere on the damp, moss-covered rocks, where not washed by the waves, and in full bloom during the early part of August.

39. Potentilla tridentata, *Ait.* Three-toothed Cinque-foil. Everywhere common on the rocks and on Minnesota Point. In the last locality it grows in the dry, loose sand.

*40. Potentilla palustris, *Scop.* Marsh Cinque-foil.—Grand Marais; common.

41. Fragaria vesca, *L.* Wild Strawberry.—Devil's Track River.

42. Rubus Nutkanus, *Mocino.* White-Flowering Raspberry.—Abundant everywhere, but especially along old trails and about clearings. Ripening fruit first week in August.

43. Rubus triflorus, *Richardson.* Dwarf Raspberry.—Common.

44. Rubus strigosus, *Michx.* Common Wild Raspberry.—Abundant and wonderfully prolific. The fruit this year principally during the latter part of August.

45. Rosa lucida, Ehrhart. Dwarf Wild-Rose. Common on sandy soil.

46. Pyrus Americana, DC. American Mountain Ash.—A common tree, attaining considerable size. Professor Winchell collected specimens where the trunk was at least 12 inches in diameter, and perfectly sound. Others, though unsound, were 15 and 16 inches.

47. Amelanchier Canadensis var. oblongifolia. June Berry.—A small tree found at Devil's Track River Aug. 21, with few mostly unripe berries could be referred only here. It seemed very late in the season for the fruit of this species to be still unripe.

SAXIFRAGACEÆ. Saxifrage Family.

*48. Ribes rotundifolium, *Michx.* Gooseberry.—Grand Marais. In fruit second week in August.

49. Ribes lacustre, *Poir.*—Gooseberry. Grand Marais. In fruit Aug. 12.

50. Ribes prostratum, *L'Her.* Fetid Currant. "Skunk-Berry."—Everywhere common.

51. Ribes rubrum, *L.* Red Currant.—Found sparingly at Black Point, with ripe fruit Aug. 24.

*52. Mitella nuda, *L.* Bishop's Cap.—Common at Grand Marais, and doubtless elsewhere.

ONAGRACEÆ. Evening Primrose Family.

53. Circæa alpina, *L.* Enchanter's Night-shade.—Abundant everywhere.

54. Epilobium angustifolium, *L.* Great Willow-herb.—Common, especially on burnt areas.

55. Epilobium palustre, *L.*, var. lineàre, Willow-herb.—Common in a marsh near Stewart River.

56. Epilobium coloratum, *Muhl.* Willow herb.—Common.

57. Œnothera biennis, *L.* Evening Primrose.—Common.

UMBELLIFERÆ. Parsley Family.

58. Heracleum lanatum, *Michx.* Cow-Parsnip.—Common.

59. Cicuta bulbifera, *L.* Water-Hemlock.—Common about a marshy pond near Stewart River.

*60. Sium lineàre, *Michx.* Water Parsnip.—Common on low-ground near Stewart River.

61. Sium Carsoni, *Durand, ined.* Water Parsnip.—Specimen doubtfully referred to this species.

ARALIACEÆ. Ginseng Family.

62. Aralia hispida, *Michx.* Bristly Sarsaparilla.—Common along the shore.

63. Aralia nudicaulis, *L.* Wild Sarsaparilla.—Woods; common. Fruiting middle of August.

CORNACEÆ. Dogwood Family.

64. Cornus Canadensis, *L.* Dwarf Cornel.—Abundant everywhere. In fruit and flower first week of August. Some blossoms appear to turn pink with age.

65. Cornus circinata, *L'Her.* Round-leaved Cornel.—Carlton's Peak, Aug. 25. In fruit.

66. Cornus stolonifera, *Michx.* Red-osier Dogwood. Kinnikinnik.—Abundant.

CAPRIFOLIACEÆ. Honeysuckle Family.

67. Linnæa borealis, *Gronor.* Twin-flower.—This pretty little plant, the Dwarf Cornel and the Clintonia are the most common small flowering plants found in the moss-carpeted forest. Out of blossom for the most part before our arrival.

68. Lonicera hirsuta, *Eaton.* Hairy Honeysuckle.—Mouth of Devil's Track River; green fruit Aug. 21.

69. Diervilla trifida, *Mœnch.* Bush Honeysuckle.—Abundant.

70. Sambucus pubens, *Michx.* Red-berried Elder.—Common. In fruit in the early part of August.

71. Viburnum Opulus, *L.* High-bush Cranberry.—Ripe fruit, Aug. 25.

RUBIACEÆ. Madder Family.

72. Galium asprellum, *Michx.* Rough Bedstraw.—Common. In bloom Aug. 21.

*73. Galium trifidum, *L.* Small Bedstraw.—Grand Marais; Beaver Bay; common.

74. Galium triflorum, *L.* Sweet-scented Bedstraw.—Common. In bloom and fruit at Grand Marais, Aug. 20.

COMPOSITÆ. Composite Family.

75. Eupatorium purpureum, *L.* Je-Pye Weed.—Abundant at Devil's Track Lake.

*76. Aster macrophyllum, *L.* Aster.—Abundant at Grand Marais and elsewhere; coming into bloom the first week of August.

77. Aster sagittifolius, *Willd.*—Very common, and in full bloom during latter part of August.

*78. Aster miser, *L.*, *Ait.*—Common.

*79. Aster simplex, *Willd.*—This or a closely allied species grew in abundance on a piece of low ground near Stewart River, forming dense, rank clumps, in full bloom Aug. 31.

80. Aster puniceusus, *L.*—Quite frequent.

81. Aster ptarmicoides, *Torr. & Gr.*—Very common all along the shore, growing in the clefts of the rocks. In full bloom the latter part of July.

*82. Erigeron Canadensis, *L.* Horse-weed.—Grand Marais.

*83. Diplopappus umbellatus, *Torr. & Gr.* Double-bristled Aster.—Abundant; just coming in bloom Aug. 11.

84. Solidago bicolor var. concolor. Golden-Rod.—Common everywhere on rocks.

*85. Solidago latifolia, *L.*—Beaver Bay; common.

*86. Solidago stricta, *Ait.*—Grand Marais; common on wet ground.

*87. Solidago arguta, *Ait.*—Common.

*88. Solidago memoralis, *Ait.*—Minnesota Point; rather common.

*89. Solidago gigantea, *Ait.*—Beaver Bay and Duluth; common.

90. Heliopsis lævis, *Pers.* Ox-eye. Grand Marais and elsewhere.

*91. Helianthus giganteus, *L.* Wild Sun-flower.—Frequent along Beaver Bay Creek.

*92. Bidens frondosa, *L.* Common Beggar-ticks.—Duluth; common.

*93. Bidens cernua, *L.* Small Bur-Marigold.—Common in a marsh near Stewart River.

*94. Maruta Cotula, *DC.* May-weed.—Duluth.

95. Achillea Millefolium, *L.* Common Yarrow.—Abundant. The rose colored variety occurs sparingly, showing all shades of color from white to a quite deep pink.

*96. Artemesia biennis, *Willd.* Biennial Wormwood.—Duluth.

*97. Antennaria margaritacea, *R. Brown.* Pearly Everlasting.—Beaver Bay; common.

*98. Cirsium undulatum, *Spreng.* Thistle.—In a grass field at Grand Marais. Said to have made its appearance the year previous,

99. Hieracium Canadense, *Michx.* Canada Hawkweed.—Abundant; blooming first week in August.

*100. Hieracium scabra, *Michx.* Rough Hawkweed.—Beaver Bay; frequent.

101. Nabalus albus, *Hook.* White Lettuce.—Grand Marais.

*102. Taraxacum Dens-leonis, *Desf.* Common Dandelion. Beaver Bay and Duluth.

*103. Mulgedium leucophæum, *DC.* False or Blue Lettuce.—Occasional.

*104. Sonchus asper, *Vill.* Sow-Thistle.—Grand Marais, Beaver Bay.

LOBELIACEæ. Lobelia Family.

105. Loblia Kalmii, *L.* Kalm's Lobelia.—Growing quite commonly in little tufts in the clefts of the rocks along the shore.

CAMPANULACEÆ. Campanula Family.

106. Campanula rotundifolia, *L.* Harebell.—Common; varying through intermediate forms to the variety *linifolia.*

107. Campanula aparinoides, *Pursh.* Marsh Bellflower.—Grand Marais; quite common. In bloom Aug. 12.

ERICACEÆ. Heath Family.

108. Vaccinium Oxycoccus, *L.* Small Cranberry.—Common in the marsh at Grand Marais and on a small island in Superior Bay.

*109. Viccinium Pennsylvanicum, *Lam.* Dwarf Blueberry.—Grand Marais.

110. Chiogenes hispidula, *Torr. & Gr.* Creeping Snowberry.—Grand Marais. In fruit near Devil's Track Lake the middle of August.

111. Arctostaphylos Uva ursi, *Spreng.* Bearberry.—Grand Marais; common. Fruit ripe in August.

112. Gaultheria procumbens, *L.* Aromatic Wintergreen.—Minnesota Point; common. In blossom Sept. 1.

*113. Cassandra caliculata, *Don.* Cassandra.—Minnesota Point; common on low ground. Grand Marais.

*114. Andromeda polifolia, *L.* Andromeda.—Common in the marsh at Grand Marais.

115. Ledum latifolium, *Ait.* Labrador Tea.—Abundant. Far advanced in fruit at Grand Marais, July 28.

116. Pyrola rotundifolia, *L.* Round-leaved Winter-Green.—Black Point.

117. Pyrola chlorantha, *Swatz.* Winter-green.—Common. Fruit Aug. 24.

118. Pyrola secunda, L. Winter-green.—Common.

119. Moneses uniflora—. One-flowered Pyrola.—Grand Marais. In blossom July, 31.

*120. Chimaphila umbellata *Nutt.* Princes Pine. Pipsisewa.—Local. Common at Devils' Track Lake and just passing out of bloom, Aug. 16. Minnesota Point; sparingly in bloom, Sept. 1.

121. Monotropa uniflora, *L.* Indian Pipe.—Common. In bloom and fruit latter part of August.

*122. Monotropa Hypopitys, *L.* Pine-sap.—Only two specimens found Caribou Point, Aug. 24 in full bloom; summit of Carlton Peak, Aug. 25, in fruit.

PLANTAGINACEÆ. Plantain Family.

123. Plantago major, L. Common Plantain.—Rove Lake Trail, etc.

PRIMULACEÆ. Primrose Family.

124. Primula Mistassinica, *Michx.* Primrose.—A very abundant plant, forming thick patches along the crevices of the rocks all along the shore. Out of blossom and fruitage on our arrival, July 27.

125. Trientalis Americana, *Pursh.* Star-flower.—Common everywhere; mostly out of blossom before Aug. 1.

126. Lysimachia stricta, *Ait.* Loosestrife.—Grand Marais; common. Came into bloom early in August.

LENTIBULACEÆ. Bladderwort Family.

*127. Utricularia vulgaris, *L.* Greater Bladderwort.—Common in a pond near Stewart River. In bloom Aug. 30.

*128. Pinguicula vulgaris, *L.* Butterwort.—Rather common about pools and wet mossy places on the rocks. Wholly out of blossom on our arrival, July 27.

SCROPHULARIACEÆ. Figwort Family.

*129. Verbascum Thapsus, *L.* Common Mullein.—Common in an old pasture at Beaver Bay.

130. Chelone glabra, *L.* Turtle-head.—Black Point; common.

131. Mimulus ringens, *L.* Monkey Flower.—Common on low ground near Stewart River. Out of bloom Aug. 30.

*132. Veronica Americana, *Schweinitz.* American Brookline.—Beaver Bay.

*133. Euphrasia officinalis, *L.* Eyebright.—Abundant everywhere about the edges of mossy thickets, especially on the rocky "peninsula" at Grand Marais. In bloom the last of July and during August. Small and little-branched in exposed situations; larger and much branched among other vegetation.

134. Melampyrum Americanum, *Michx.* Cow-Wheat.—Minnesota Point; common. In bloom and fruit Sept. 1.

LABIATÆ. Mint Family.

*135. Mentha Canadensis, *L.* Wild Mint.—Grand Marais; common.

136. Lycopus Virginicus, *L.* Bugle-weed.—Common.

*137. Nepeta Cataria, *L.* Catnip.—Grand Marais; about an old garden.

138. Brunella vulgaris, *L.* Self-heal.—Beaver Bay; common.

*139. Scutellaria galericulata, *L.* Scullcap.—Cascade River. Grand Marais.

*140. Scutellaria lateriflora, *L.* Mad-dog Skullcap.—Rove Lake Trail.

141. Galeopsis Tetrahit, *L.* Common Hemp-Nettle.—Very common; growing on the shingle especially. Corolla almost universally white, marked with yellow in the throat; rarely purple.

*142. Stachys palustris var. asper. Hedge-Nettle.—Little Marais. Palisades, Aug. 26; common and in bloom. The variety *cordata* common near Stewart River.

BORRAGINACEÆ. Borage Family.

143. Mertensia paniculata, *Don.* Smooth Lungwort.—Abundant. The flower buds pink, turning blue as they open, thus giving the flowering plant a showy, varigated appearance. Still blooming in August.

GENTIANACEÆ. Gentian Family.

144. Halenia deflexa, *Grisebach.* Spurred Gentian.—Common.

145. Menyanthes trifoliata, *L.* Buckbean.—Grand Marais. D. T. Lake. Out of bloom.

CHENOPODIACEÆ. Goosefoot Family.

*146. Chenopodium album, *L.* Lamb's Quarters.—Grand Marais; on cultivated ground.

*147. Blitum capitatum, *L.* Strawberry Blite.—Minnesota Point. Ripe fruit and blossoms, Sept. 2.

*148. Corispermum hyssopifolium, *L.* Bug-seed.—Common on Minnesota Point. [It may be of interest to note that this plant also occurs in the vicinity of Minneapolis, though not heretofore reported from the State.]

AMARANTACEÆ. Amaranth Family.

*149. Amarantus retroflexus, *L.* Pigweed.—Duluth; common.

*150. Montelia tamariscinia,—.Common on Minnesota Point and about Duluth.

POLYGONACEÆ. Buckwheat Family.

*151. Polygonum viviparum, *L.* Albine Bistort.—A single plant in bloom, and with many red bulblets, found at Grand Marais, Aug. 21.

*152. Polygonum Persicaria, *L.* Lady's Thumb.—Common.

*153. Polygonum Hydropiper, *L.* Common Smart-weed.—Duluth; common.

*154. Polygonum acre, *H. B. K.* Water Smartweed.—Common.

*155. Polygonum amphibium var. terrestre, *Willd.* Water Persicaria.—Common near Stewart River, and one form close to rarity *aquaticum.*

*156. Polygonum articulatum, *L.* Joints red. Common and in full bloom Sept. 1, on Minnesota Point. A very pretty plant, growing in the dry sand.

*157. Polygonum aviculare, *L* Knotgrass.—Common.

*158. Polygonum sagittatum, *L.* Arrow-leaved Tear-thumb.—Common around a pond near Stewart River.

*159. Polygonum Convolvulus, *L.* Black Bindweed.—Common about cultivated grounds.

160. Polygonum cilinode, *Michx.* Black Bindweed.—Abundant; springing up in profusion on burnt areas.

*161. Rumex orbiculatus, *Gray.* Great Water Dock.—Near Stewart river; common.

162. Rumex Acetosella, *L.* Sheep Sorrel.—Common all along the shore.

CALLITHRICHACEÆ. Water Starwort Family.

*163. Callitriche verna, *L.* Water Starwort.—Common: Pallisades, Duluth, etc. Growing both in and out of water. Fruit and flowers, Sept. 2.

URTICACEÆ. Nettle Family.

164. Urtica gracilis Ait. Common Nettle.—Common.

CUPULIFERÆ. Oak Family.

165. Corylus rostrata, *Ait.* Beaked Hazel-nut.—Common; in fruit Aug. 5.

BETULACEÆ. Birch Family.

166. Betula papyracea, *Ait.* Paper Birch.—Abundant everywhere. The bark of this tree, together with that of the "Cedar" (Arbor-vitæ), is made use of in innumerable ways by the Indians.

167. Alnus viridis, D. C. Green Alder.—Common. Forming small clumps along shore, wherever it can get a foot-hold.

SALICACEÆ. Willow Family.

168. Populus tremuloides, *Michx.* American Aspen.—Abundant.

CONIFERÆ. Pine Family.

169. Pinus Banksiana, *Lambert.* Northern Scrub Pine.—Common.

170. Pinus Strobus, L. White Pine.—Common; but there is no extensive pine forest on the immediate shore.

171. Abies niger. *Pair.* Black Spruce.

172. Abies alba, *Michx.* White Spruce.

173. Abies balsamea, *Marshall.* Balsam Fir.

174. Larix Americana, *Michx.* Tamarack.—Common, growing often on high ground.

175. Thuja occidentalis, *L.* American Arbor-vitæ. Forming the dense, almost impenetrable "cedar-swamps" of this region. Attains a large size —two to three feet in diameter.

176. Juniperus communis, *L.* Common Juniper. Minnesota Point; common.

177. Taxus baccata, *L.*, var. Canadensis. Am. Yew. Ground Hemlock. —Abundant. Fruit ripe during August.

ARACEÆ. Arum Family.

178. Cala palustris, *L.* Water Arum.—Stewart river. Common about Duluth; blooming in July.

179. Acorus Calamus, *L.* Sweet Flag.—Duluth; common.

LEMNACEÆ. Duckweed Family.

*180. Lemna minor, *L.* Duckweed.—Duluth harbor; common.

TYPHACEÆ. Cat-tail Family.

*181. Typha latifolia, *L.* Common Cat-tail.—Duluth; common.

NAIADACCEÆ. Pond-weed Family.

* ? 182. Potamogeton Claytoni, *Tuckerman.* Pond-weed.—Common in a small stream near Stewart River.

*183. Potamogeton amplifolius, *Michx.*—Devil's Track Lake; common.

*184. Potamogeton gramineus, *L.*—Devil's Track Lake; abundant. Fruiting middle of August.

ALISMACEÆ. Water-Plantain Family.

*185. Triglochin maritimum, *L.* var. elatum. Arrow-Grass.—Duluth; common.

*186. Alisma Plantago, L., var. Americanum. Water-Plantain.—Duluth; abundant. Blossom and fruit Sept. 2.

*187. Sagittaria variabilis, *Engelm.* Arrow-head.—Common near Stewart River.

HYDROCHARIDACEÆ. Frog's-bit Family.

*188. Anacharis Canadensis, *Planchon.* Water-weed.—Duluth harbor; common.

*189. Vallisneria spiralis, *L.* Eel-grass. Water Celery.—Duluth harbor; common.

ORCHIDACEÆ. Orchis Family.

*190. Habenaria viridis, *R Br.*, var. bracteata, Reichenbach. Rein-Orchis.—Carlton's Peak, Aug. 25; in bloom.

191. Habenaria obtusata, *Richardson.* Rein-Orchis.—Abundant; blooming July and August.

192. Habenaria orbiculata, *Torr.* Orchis.—Devil's Track River.

*193. Goodyera repens, *R. Br.* Rattlesnake-Plantain.—Abundant.

*194. Calopogon pulchellus, *R. Br.* Grass Pink.—Common on a small island in Superior Bay. Blooming middle of July [1877.]

*195. Calypso borealis, *Salisb.* Calypso.—Some dead scapes and flowers collected at Black Point, Aug. 24, are evidently referable to this species.

IRIDACEÆ. Iris Family.

196. Iris versicolor, L. Large Blue Flag.—Grand Marais; common.

LILIACEÆ. Lily Family.

*197. Trillium cernuum, *L.* Wake-Robin.—Grand Marais. In fruit Aug. 15.

*198. Streptopus roseus, *Michx.* Twisted-Stalk.—Common. Fruiting during August.

199. Clintonia borealis, *Raf.* Northern Clintonia.—Abundant and in fruit.

*200. Smilacina bifolia, *Ker.* False Solomon's Seal.—Common.

201. Smilacina trifolia, *Desf.* False Solomon's Seal.

202. Lilium Philadelphicum, *L.* Wild Orange-red Lily.—Occasional along the shore.

FELICES. Ferns.

203. Polypodium vulgare, *L.* Polypody.—Abundant; growing on the rocks.

204. Pteris aquilina, *L.* Common Bracke.—Common about Devil's Track Lake and along Rove Lake Trail.

*205. Asplenium Filix-fœmina, Bernh. Spleenwort.—Common.

*206. Phegopteris polypodioides, *Fée.* Beech-Fern. Abundant.

*207. Phegopteris Dryopteris, *Fée.* Beech Fern.—Common everywhere.

*208. Aspidium spinulosum, *Swartz.* var. dilatatum. Wood-Fern.—Cascade River.

*209. Cystopteris bulbifera, *Bernh.* Bladder-Fern.—Cascade River.

*210. Cystopteris fragilis, *Bernh.* var. dentatum, *Hook.* Bladder-Fern.—Cascade River.

211. Onoclea sensibilis, *L.* Sensitive-Fern.—Abundant along the Devil's Track River.

*212. Woodsia Ilvensis, *R. Brown.* Woodsia.—Very common on the rocks all along the shore. A dwarf form, one to three inches high, yet fruiting freely, was common in the clefts of the rocks on the summit of Carlton Peak.

*213. Osmunda regalis, *L.* Flowering-Fern.—Common along Devil's Track River.

*214. Osmunda Claytoniana, *L.* Flowering-Fern.—Rove Lake Trail.

*215. Osmunda cinnamomea, *L.* Cinnamon-Fern.—Common.

LYCOPODIACEÆ. Club-Moss Family.

*216. Lycopodium lucidulum, *Michx.*—Carlton's Peak; abundant. Mouth of Devil's Track River.

217. Lycopodium annotinum, *L.* Common everywhere.

218. Lycopodium dendroideum, *Michx.* Ground Pine.—Common.

219. Lycopodium clavatum, *L.* Common Club Moss.—Common.

220. Lycopodium complanatum, *L.*—Devil's Track Lake; rather common.

# VII.

# CHEMISTRY.

## REPORT OF PROF. PECKHAM.

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*Prof. N. H. Winchell:*

MY DEAR SIR: Permit me to submit the following report of Chemical work done for the Geological Survey since my last report.

The three specimens of iron ore, numbered 58, 61 and 62,* were examined in accordance with the instructions conveyed by your letter of June 10th, 1879, as follows:

In the analysis of the iron ores, determine the following:

Insol. siliceous matter.
Sulphur (or Sulphuric Acid.)
Phosphorus (or Acid.)
Lime.
Magnesia.
Manganese Oxide.
Alumnina.
Iron as metal.
Iron as protoxide.

(Signed) N. H. WINCHELL.

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* In the Seventh Annual Report were given the Analysis of:
No. 55. A Siliceous Magnesian Limestone, from Tom's Quarry, Sugar Loaf, Winona.
No. 56. Limestone from Shakopee, (Museum number 2165).
No. 57. Limestone from Clapp's Quarry, (Shakopee formation), near Mankato.
Other numbers are from the following localities:
No. 58. Siliceous Iron Ore, four miles west of Cannon Falls, (Mus. No. 418).
No. 59. Close-grained Limstone, Le Roy, (Mus. number 2238).
No. 60. Red Quartzyte, from the Pipestone quarry.
No. 61. Iron Ore, from the Mesabi Range, (Survey No. 438, of field-book No. 38.)
No. 62. Iron Ore, from the Mesabi Range, (Survey No. 441, of field-book 38).
No. 63. St. Lawrence Limestone, Winona, (Museum No. 219).
No. 64. Shakopee Limestone, from Kasota. The Kasota building stone.
No. 65. St. Lawrence Limestone, from St. Lawrence, with green sand, (Mus. No. 2169).
No. 66. Combustible Shale, Lower Trenton, Prairie Creek quarries, Rice Co., (Mus. No. 2564).
No. 67. Cretaceous Clay (or Shale), Mankato, (Mus. No. 2159).
[N. H. W.]

The results obtained are given below.

IRON ORES.

| Number. | 58. | 61. | 62. |
|---|---|---|---|
| Insoluble siliceous matter | 47.75 | 14.98 | 16.29 |
| Sulphur or Sulph. Acid, $SO_3$ | .120 | .32 | .27 |
| Phosphorus (or Acid), $P_2 O_5$ | .002 | none. | trace. |
| Lime, Ca O | trace. | trace. | trace. |
| Magnesia, Mg O | trace. | trace. | trace. |
| Manganese Oxide, Mu O | trace. | 2.13 | .094 |
| Alumina, $Al_2 O_3$ | .700 | 3.35 | .92 |
| Ferric Oxide, $Fe_2 O_3$ | 51.017 | 76.7297 | 45.554 |
| Iron, Fe | 35.7137 | 53.7134 | 59.999 |
| Ferrous Oxide, Fe O | none. | none. | 36.143 |
| Magnetic Oxide, $Fe_3 O_4$ | none. | none. | 82.858 |

Numbers 61 and 62 are pure and valuable iron ores.

Number 63 is a limestone, containing druzy cavities filled with white quartz. It consists of:

| | Per cent. |
|---|---|
| Insoluble matter | 6.58 |
| Soluble Silica, Si $O_2$, Aluminic Oxide $Al_2 O_3$ and Ferric Oxide, $Fe_2 O_3$ | 14.26 |
| Calcium Carbonate, Ca $CO_3$ | 39.338 |
| Magnesium Carbonate, Mg $CO_3$ | 34.734 |
| Sulphuric Oxide, $SO_3$ | trace. |
| Undetermined Alkaline Carbonates | 5.088 |
| | 100.000 |

Number 64 is a remarkably pure Magnesian limestone. It consists of:

| | |
|---|---|
| Insoluble matter, (chiefly Silica) Si $O_2$ | 13.85 |
| Soluble Silica, $SiO_2$, Alumnic Oxide $Al_2$, $O_3$, and Ferric Oxide $Fe_2 O_3$ | 1.[illegible] |
| Calsium Carbonate, Ca C $O_3$ | 47.9[illegible] |
| Magnesium Carbonate, Mg C $O_3$ | 35.22[illegible] |
| Sulphuric Oxide $SO_3$ | trace. |
| Water and Alkalies, undetermined | 1.529 |
| | 100.000 |

Number 65 appeared to the eye to be identical with number 31—the St. Lawrence limestone—containing Glauconite, already reported,* to you in my report dated Jan. 9th, 1877.

The portion of the rock that is soluble in cold hydrochloric acid contained:

Calcium Carbonate, Ca $CO_3$
Magnesium Carbonate, Mg $CO_3$

*See Report State Geologist, Minnesota, 1876, pg. 61.

Calcium Silicate, $Ca_2 Si O_3$
Ferrie Oxide, $Fe_2 O_3$
Manganic Oxide, Mn O.

Angular grains of silica and small green grains remained undissolved. The green grains varried in size from one thirty-second (estimated) of an inch in diameter to those of inappreciable dimensions. Most of the grains of silica were about the size of mustard seed, but many of them were extremely small, rendering the complete separation of the grains of silica and the green grains impossible. It was also found impossible to make any two estimates of the composition of the soluble portion that would correspond. The insoluble silica and green grains both together and separately are not uniformly distributed through the rock, so that only an aproximation can be made of the mixture of which the rock is composed. Of the piece examined 6.771 per cent. was insoluble. I think the piece selected was a fair average. The analysis of the green gains will be found to correspond very closely with that before reported.*

| | Per cent. |
|---|---|
| Silicic Oxide, $Si O_2$ | 48.131 |
| Ferrous Oxide, Fe O | 27.063 |
| Aluminic Oxide, $Al_2 O_3$ | 6.962 |
| Manganic Oxide, Mn O | trace. |
| Calcium Oxide, Ca O | trace. |
| Potassium Oxide) $K_2 O$ | 6.982 |
| Sodium Oxide, $Na_2 O$ | 1.931 |
| Water, $H_2 O$ | 8.841 |
| | 99.910 |

These results, like those previously reported, indicate a glauconite insoluble in hydrochloric acid.†

Number 66 is a shale or clay containing organic matter and calcium carbonate. Sixty-one per cent. is insoluble in hydrochloric acid. This insoluble material consists of:

| | |
|---|---|
| Organic, combustible matter | 22.87 |
| Silicic Oxide $Si O_2$ | 25.20 |
| Aluminic Oxide, $Al_2 O_3$ plus a trace of Ferric Oxide, $Fe_2 O_3$ | 8.96 |
| Barium Sulphate, $Ba SO_4$ | 3.0057 |
| Magnesium Oxide, MgO | .973 |
| Calcium Oxide, CaO | trace. |
| The soluble material consisted of: | |
| Ferric Oxide, $Fe_2 O_3$ plus Aluminic Oxide, $Al_2 O_3$ plus a trace of Ferrous Oxide, FeO | 2.20 |
| Calcium Carbonate, $Ca CO_3$ | 20.809 |
| Calcium Sulphate, $Ca SO_4$ | .2035 |
| Magnesium Carbonate, $Mg CO_3$ | 12.986 |
| Water and trace of alkalies | 2.7928 |
| | 100.0000 |

It is quite possible that this shale, if mixed with clay in proper proportion

*Ibid.

†Dana's Min. Geology, Ed. 1870, page 462.

and burned, would furnish hydraulic cement. The burning would require very little extra fuel.

Number 67 is a highly siliceous clay. Its composition places it with orthoclase, although it has the physical properties of kaolin. It is chemically a slightly decomposed feldspar, while it has the appearance and some of the properties of clay. It, however, appears to contain too much iron to admit of its being used for white ware, although a practical test is often required to definitely settle the value of clays for such purposes. It was found, on analysis, to contain:

| | Per cent. |
|---|---|
| Water, $H_2O$ | 1.980 |
| Silicic Oxide, $SiO_2$ | 70.100 |
| Aluminum Oxide, $Al_2O_3$ plus Ferric Oxide, $Fe_2O_3$ a trace | 16.990 |
| Sulphuric Oxide, $SO_3$ | 00.231 |
| Potassium Oxide, $K_2O$ | 10.695 |
| | 99.996 |

Very respectfully yours,

S. F. PECKHAM,
Chemist to the Geol. Survey.

THE UNIVERSITY OF MINNESOTA,
Jan. 28, 1880.

# VIII.

## ORNITHOLOGY.

### REPORT OF DR. P. L. HATCH.

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*Prof. N. H. Winchell*—

DEAR SIR: The increased facilities for extending my observations over new sections of the State, which your considerations afforded me, have enabled me to achieve more satisfactory results than in the preceding year.

I not only visited remote points of great interest, but have thus succeeded in enlisting competent assistants who have entered into the exploration of their special localities with great enthusiasm. Several such have given me carefully prepared reports of what they have accomplished, which I reserve to draw upon in making up my final report. I have held several such over the last year from Messrs. T. S. Roberts, C. L. Herrick, R. L. Williams and E. L. Hood, which, but for a little misapprehension, I should have handed you a year ago.

I am gratified, however, to know that they do not regret the omission. I am under renewed obligations to these young and enthusiastic naturalists for their hearty co-operation. They will pardon my constitutional caution in not publishing observations in natural history prematurely: they are better, sometimes, like wine, for having been kept a time. It is often the case that but *half* of the truth is a *whole* falsehood. I am anxious to gather data from more than half of the field before attempting to extract reliable truth for the whole. However, I have a paper from your assistant, Prof. C. W. Hall, prepared by Mr. T. S. Roberts, his assistant, in a Geological and Natural History exploration of the north-west shore of Lake Superior, that is so complete in itself and covers a hitherto unexplored region of such interest to ornithologists, that I cannot withhold it for my completed report without injustice, not only to those gentlemen, but to all who are interested in the fauna of that interesting region. You will find it inclosed herewith. With renewed assurances of my interest in the work I have undertaken and my sincere acknowledgments for your official and personal kindness uniformly manifested to me, I remain,

Yours very truly,

P. L. HATCH.

No. 818 Nicollet Av., Minneapolis, March 5, 1880.

*Dr. P. L. Hatch, State Ornithologist—*

SIR: I transmit to you herewith a list of birds collected by Mr. Thomas S. Roberts. During the past summer a geological and collecting corps of the Geological and Natural History Survey of this State was sent by the State Geologist to the northwest shore of Lake Superior for studying certain geological and mineralogical characters along the cost, and for making collections of the fauna and flora of that region, that the same might be represented in the General Museum of the University.

Mr. Roberts was my assistant on that expedition, and I am pleased to have an opportunity here to bear record to his untiring industry and patience, to his quickness and exactness in observation, and to the thoroughness with which he followed out the details of every examination.

The skins of the birds collected and the sterna and parts of the viscera of many of them are in the Museum of the Univerity, where yourself and all others interested in Ornithology can have free access to them for study and comparison.

Very truly yours,

C. W. HALL.

THE UNIVERSITY OF MINNESOTA, Feb. 25, 1880.

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# A PARTIAL LIST

OF THE

# BIRDS OF ST. LOUIS AND LAKE COUNTIES, MINN.

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These two counties, St. Louis and Lake, form the triangle which projects eastward from the northern half of the State of Minnesota, between Lake Superior and the British possessions. Each is of large dimensions, and together they form an extensive tract of country, representing the wild, heavily timbered area of the State. This list of birds, however, relates only to a narrow strip along the lake shore, between the mouths of the St Louis and Devil's Track Rivers—a general coast line of about one hundred and twelve miles. From Grand Marais, one hundred and eight miles below Duluth, a collecting trip was made six or eight miles inland to a sheet of water known as Devil's Track Lake. This proved to be a quite large and pretty lake, with low, rocky shores and timber growing to the very water's edge. From its eastern end flows the river of the same name, a considerable stream, which, after receiving several affluents and making a descent of over a thousand feet, enters Lake Superior about four miles below Grand Marais.

This whole extent of country is covered with a dense forest, consisting for the most part of evergreens, white birch and poplar, which everywhere encroaches close upon the water's edge, whether it be along the banks of the rivers or the shore of the lake. Indeed, it is alone the action of the

water that establishes the line beyond which the trees cannot advance, and owing to the abrupt, rocky character of the entire shore this line is close to the water and very sharply defined. It is but a step from the gloomy forest to the bare rock or shingle beach, and usually but a half dozen more down over the water-worn rock to the icy waters of the lake itself. The rivers, entering the lake, between rocky walls, and with scarcely an opening among the trees, vary but little the general uniformity of the forest line. About the only breaks in this monotony are "burns," small areas from which the timber has been cut, and now and then a hard-earned clearing which has most likely been abandoned to grow up in saplings and brush. Aside from the low ground about the mouth of the St. Louis River, only two small marshes, scarcely worthy of mention, were seen. One of these constitutes the *marais* from which Grand Marais takes its name, and the other, of somewhat greater dimensions, lies just above Stewart River. Neither is directly connected with the lake.

Every field ornithologist is aware that birds, as a rule, do not like the deep, sombre forest, but frequent by preference the edges of woods or open spots where they can get air and sun-light as well as suitable food. This is well illustrated on the "North Shore;" for the vicinity of towns, abandoned clearings, and old burnt sections were found to be by far the best collecting grounds. A long walk through the forest, resulted generally in hearing only a few Red-eyed Vireos singing high up among the trees, encountering perhaps a noisy, roving troop of Chickadees or a few warblers, stragglers from the outside, flitting about among the tree-tops.

Near Duluth are marshes and a number of cultivated fields, and we find that such birds as the Yellow-winged and Savanna Sparrows, Grass Finch, Bobolink, etc., are to be found. But other than in these two localities there is little or no cultivated ground within the region examined. At Grand Marais, which was our headquarters, there are two or three large partial clearings and a low ⊣ shaped peninsula, which bears only bushes and stunted trees, conditions which make this a fair locality for the bird-collector.

Considerable disappointment was felt at not finding several species of birds that were confidently looked for, and which, in all probability, do occur. Among these may be named the Mourning Warbler, Canada Jay, White-winged Crossbill, Banded Three-toed Woodpecker, Pileated Woodpecker and two or three species of owls. The Canada Jay and Pileated woodpecker were known to residents, and the former said to be common and noticeable in the fall and winter. Owls appeared to be scarce. We ourselves noted but few, though camping along the shore for over five weeks, and little could be learned of them from resident hunters.

The work of the present season (1879) was included between the dates July 26th and September 2d. In July, 1877, the writer spent a few days collecting at Duluth, and as the notes taken at that time have never been published, they are incorporated in this list in order to render it as full as possible. All matter introduced from this source is inclosed in brackets, as the work was done independent of the survey.

One hundred and twenty-five (125) skins representing fifty-five (55) species, were taken the present season. Seven (7) additional species are represented in the University Museum, and the writer's collection by speci-

mens previously taken on the north shore, which makes sixty-two (62) species that rest on the capture of specimens. The remainder were seen and well identified by the writer with the exception of a single species,—the White-headed Eagle, which is included upon hearsay.

The name of a locality accompanied by only a date signifies that the species was taken at that time and place. These records of capture have been introduced quite frequently as giving a degree of definiteness to the observations.

1. [Turdus migratorius, *Linn.* Robin.—Common at Duluth in July, 1877,]

2. [Turdus swainsoni, *Cab.* Olive-backed Thrush.—A specimen (var. *swainsoni*) was taken at Duluth, July 16, 1877.]

3. [Sialia sialis, (*Linn.*) *Hald.* Blue-bird.—Several pairs seen at Duluth in July, '77.]

4. Parus atricapillus, *Linn*, Black-capped Chicadee.—Common. Found often in the deep woods where few other birds live.

5. Sitta canadensis, *Linn.* Red-bellied Nuthatch.—Not very common. Its trumpet like notes betraying its presence much oftener than a sight of the bird itself. Poplar River, Aug. 6.

6. Certhia familiaris, *Linn.* Brown Creeper.—Noted quite frequently. Seen at Grand Marais July 28 and on Minnesota Point, Sept. 1.

7. Troglodytes aedon parkmani, Western House Wren.—Taken at Grand Marais, where several were seen. I am at a loss to account for the apparent scarcity of this species along the shore as I found it in July, 1877, very common among the burnt and fallen timber about the Northern Pacific Junction and Duluth. A number of specimens taken at that time show a very light coloration; and in fact all the wrens of this species that I have taken in Minnesota are noticeably light colored. In view of this fact I recently sent a small series of skins from different localities in the State to Mr. Robt. Ridgway for identification. His reply was that the specimens were all *parkmani*, and extremely typical of that form. Again in a subsequent letter he says "Your wrens surprised me very much, as I was prepared to find them *aëdon*. They are the *most* typical specimens of *parkmani* I ever saw."

Mr. T. M. Trippe in his paper* upon the birds of central Minnesota gives Bewick's Wren as common and breeding, and includes the House Wren only with doubt. Yet in this same general region I have found only the House Wren abundant during the breeding season and have never seen Bewick's Wren.

8. [Mniotilta varia, (*Linn.*) *Vieill:* Black and White Creeper:—Seen on Minnesota Point, July 11, 1877.]

9. Helminthophaga ruficapilla, (*Wils*) *Bd.* Nashville Warbler.—Common in latter part of August. Devil's Track Lake, Aug. 18. Beaver Bay, Aug. 28, etc.

10. Helminthophaga peregrina, (*Wils*) *Cab.* Tennessee Warbler.—Very common; forming often the greater part of the rambling companies of migrants found in open places and on the edges of the timber after the second week in August. In full song at Devil's Track Lake on Aug. 16. Grand Marais, Aug. 13. Beaver Bay, Aug. 27, etc.

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*Proc. Ess. Inst. VI. 1871, p. 115.

11. [Dendrœca æstiva, (*Gm*) *Bd.* Yellow Warbler.—Several noted at Duluth in July, 1877.]

12. Dendrœca virens, (*Gm*) *Bd.* Black-throated Green Warbler.—Grand Marais; two specimens taken July 28 and Aug. 13. [Duluth, July 16, '77.]

13. Dendrœca cœrulescens, (*Linn*) *Bd.* Black-throated Blue Warbler.—Two males taken at Poplar River, Aug. 6. From the anxiety displayed by one of these it seemed that the young were still under the care of the parents. The second male was in full song.

14. Dendrœca coronata, (*Linn*) *Gray.* Yellow-rumped Warbler.—Common at Devil's Track Lake, Aug. 16–18. Three specimens (young) taken the 16th.

15. Dendrœca blackburniæ, (*Gm.*) *Bd.* Blackburnian Warbler. A female accompanied by her brood of young was found on Aug. 10 among the dense underbrush of an old clearing at Grand Marais. They kept close to the ground, chirping constantly, and were very difficult to start from their place of concealment. Two of these were secured. Devil's Track Lake, Aug. 18.

16. Dendrœca striata, (*Forst.*) *Bd.* Black-poll Warbler.—Beaver Bay, Aug. 27, '79 (a young bird).

17. Dendœca castanea, (Wils.) Bd. Bay-breasted Warbler.—Devil's Track Lake, Aug. 16. Seen also at Black Point Aug. 24.

18. Dendrœca maculosa (*Gm.*) *Bd.* Black and Yellow Warbler.—Common. Found in small companies during the first part of August, the broods having not yet broken up. Moulting at this time. Devil's Track Lake, Aug. 16. Beaver Bay, Aug. 27.

19. Dendrœca palmarum, (*Gm.*) *Bd.* Yellow-red-poll Warbler.—Apparently not common. Beaver Bay, Aug. 27.

20. Dendrœca tigrina, (*Gm.*) Bd. Cape May Warbler.—Taken at Grand Marais, Aug. 13, and believed to have been seen at Devil's Track Lake, Aug. 16.

21. [Siurus auricapillus, (*Linn.*) *Sw.* Golden-crowned Thrush.—Several noted at Duluth in July, '77.]

22. Siurus nævius, (*Bodd.*) *Coues.* Small-billed Water Thrush.—Common at Devil's Track Lake. A thick growth of evergreens and birches, growing close to the water's edge and projecting out low over the water for a number of feet, formed a most congenial haunt for this bird. Though so late in the season (Aug. 15–18) they were uttering their ringing, emphatic song with seemingly all the vigor of spring. They sang chiefly in the morning, from daylight until eight or nine o'clock, and then again for a short time in the evening. As stated by several authors, the song bears a striking resemblance to that of the Mourning Warbler (*Geothlypis philadelphia*). Seen on the lake shore only at Black Point, Aug. 24.

23. Geothlypis trichas, (*Linn.*) *Cab.* Maryland Yellow-throat.—Seen only once, near Stewart river, Aug. 30. [Common at Duluth, in July, '77.]

24. Geothlypis philadelphia, (*Wils.*) *Bd.* Mourning Warbler.—Common about Duluth in July, 1877. The following extract from a paper contributed by the writer to the Linnean Society of New York City, in February, 1879, may be of interest in this connection. In the vicinity of Minneapolis it [*G. philadelphia*] has been met with very rarely and only during the migrations. Its capture, several years ago, by Dr. P. L. Hatch and Mr. W. L. Tiffany; the taking of two males on May 18, 1877, by Mr. R. S. Williams,

and a male of the year on Sept. 2, 1876, by the writer, about comprises its history in this locality. Dr. Hatch's words, "rare and unnoted," convey a correct idea of its occurrence here.

"Leaving Minneapolis we will pass due north about one hundred and twenty-five miles, into Carlton and St. Louis counties. Here is one vast extent of forest, largely of pines and other evergreens, but with hardwood ridges and tamarack swamps interspersed. In many sections extensive fires have raged on the low grounds during dry seasons, completely killing the timber, especially in white-birch regions. The fallen, charred timber, piled promiscuously among the dense tangled undergrowth that springs up, forms as pathless and impenetrable a place as one can well imagine, and the dead and blasted trees which remain standing on all sides, give to the country a most desolate appearance. Among several features rendering these barren wastes attractive to the ornithologist, is their being the summer home of the Mourning Warbler. During the second and third weeks of July, 1877, we found this warbler about the Northern Pacific Junction (Carlton Co.) and Duluth (St. Louis Co.) in such numbers as to fully warrant its being called common. It was at that time in song and breeding. The males were conspicuous from their habit of sitting on the dead trees to sing; but the females were seldom seen, as they kept down in the thick cover. The males would sit for a long time on the limb of a dead tree, motionless, but for the occasional utterance of their brief song. In quality their singing is much like that of the Maryland Yellow-throat; but the song, as I heard it, consists of five notes, the first three just alike, followed by two others, louder and fuller. The whole is loud, clear and ringing and forms an interesting song, but I suspect its attractiveness is due, in great measure, to the fact that it is the utterance of the Mourning Warbler. When the singer is disturbed he either flies to another tree, near by, to continue his performance or dives into the thickets below, where he is safe until he may see fit to reappear.

"The nest we did not find, though we greatly excited several pairs by our close approach to it. When thus disturbed, both male and female would utter forcible sparrow-like chirps, move actively from bush to bush, frequently passing nervously over every limb and twitching their bodies much in the manner of the Yellow-throat (*G. trichas*) under similar circumstances. A few, at least, had young upon our arrival (July 6), and we several times saw them (male as well as female) carrying large green caterpillars, such as one could scarcely imagine a young Mourning Warbler swallowing. On July 18th, at the N. P. Junction I came upon a brood of young out of the nest, but not able to fly above a few yards. They were in a dense place and kept close to the ground, only appearing for an instant now and then, when beaten from some bush. They chirped loudly, very much like the old birds. As late as July 18, at the date of our departure, the males were still in song.

"T. M. Trippe found this warbler abundant and breeding through the central part of this State in the summer of 1870, and to him is due the credit of ascertaining that the timber wilds of Minnesota are so eminently its home.

"It is a strange fact that the Morning Warbler should be so rare about Minneapolis during the migrations and yet so common all the season little more than a hundred miles farther to the north. It would seem that they must certainly pass by here; yet in what manner is something of a mystery.

The unsuitable character of the country is the evident explanation of their absence during the summer."]

Contrary to expectation nothing was seen of the species the present season, but the vicinity of Duluth was examined scarcely at all. Though why certain burned areas about Grand Marais and elsewhere were not inhabited by this bird is not quite evident.

25. Myiodioctes pusillus, (*Wils.*) Bp. Wilson's Blackcap.—Noticed several times in the latter part of August. In song. Beaver Bay, Aug. 27.

26. Myiodioctes canadensis, (*Linn.*) *Aud.* Canadian Flycatcher—Common; frequenting the undergrowth. During the early part of August its actions indicated that it was still looking after its young. In song at Devil's Track Lake, Aug. 15–18. Taken at Poplar River, Aug. 4; Grand Marais, Aug. 13.

27. Setophaga ruticilla, (*Linn.*) Sw. Redstart.—Common. A pair seen at Poplar River, Aug. 6, feeding young not more than two or three days from the nest. Grand Marais, Aug. 9.

28. [Pyranga rubra, (*Linn.*) *Vieill.* Scarlet Tanager.—A male, seen at Duluth, July 16, '77.]

29. [Tachycineta bicolor, (*Vieill.*) *Cab.* White-bellied Swallow.—Common at Duluth in July, '77.]

30. Hirundo horreorum, *Barton.* Barn Swallow.—A single male flew around the boat between Poplar and Cascade rivers on Aug. 4 and [several were seen at Duluth in July, '77.]

31. Petrochelidon lunifrons, (*Say*) *Scl.* Cliff Swallow.—One seen between Beaver Bay and Duluth.

32. Progne purpurea, (*Linn.*) *Boie.* Purple Martin.—Common. Mr. Thos. Mayhew, of Grand Marais, told us that they occupied his Martin box last season; but none were present this year. The last week of August many large loose flocks were seen flying south-westward and keeping over the water a short distance from shore.

33. Ampelis cedrorum, (*Vieill.*) *Cab.* Cedar Bird.—One of the commonest birds of this region. They occurred both in small flocks and in pairs, and some evidently had nests in the latter part of August. No young of the year were seen. At Devil's Track Lake in particular they were observed to display their ability as fly-catchers to an extent not before noticed by the writer. Regularly each morning and evening they were perched on the tops of the tallest trees about the lake shore, making sallies in all directions after passing insects and returning again to their station, almost like so many pewees or King Birds.

34. Vireo olivaceus (*Linn.*) *Vieill.* Red-eyed Vireo.—Common, and one of the few birds found regularly in the deep forest, where its song was often the only sound to break the stillness. Beaver Bay, Aug. 28.

35. [Vireo solitarius, (*Wils.*) *Vieill.* Solitary Vireo.—A single individual seen at Duluth, July 16, '77.]

36. [Carpodacus purpureus, (*Gm.*) *Gray.* Purple Finch.—A young bird taken at Duluth, July 16, '77, and others seen.]

37. Loxia curvirostra, americana, (*Wils.*) *Coues.* Red Crossbill.—Common all along the shore, but noticed more particularly at Poplar River and Grand Marais. They were in pairs or small parties of six or eight individuals, and gave evidence of a restless, roving disposition. Alighting, they would feed

industriously about the tops of the evergreens for a short time, when all of a sudden, at the sound of a few sharp notes, uttered by one of the party, they were off over the forest with wayward, erratic flight, sounding their call note as they went. They are not at all shy, but on the contrary are tame and unsuspecting birds. The roof of a house, the immediate door-yard, a tree standing close beside a dwelling are as likely resorts as other equally suitable localities. A tall, isolated pine, standing but a few feet from our shanty at Grand Marais, was a favorite stopping place for birds of this kind, and on several occasions they descended to feed about the very door, giving but little heed to the presence of the inmates.

The adults were frequently found paired and the evidence afforded by dissection seemed to indicate that they were breeding. Yet this could scarcely have been the case, since this bird is known to be one of the earliest to nest. Much attachment existed between these mated birds. On one or two occasions the male of a pair being shot first, the female flew only a short distance and remained calling loudly, until the gun was recharged and the tragedy ended by placing her beside her mate.

Only once was the species heard to sing and then (Aug. 5) it was but snatches of an apparently pleasing song.

38. Chrysomitris pinus, (*Wils.*) *Bp.* Pine Linnet.—Common. A tame, familiar species, going at this season of the year in small flocks. They fed about a fish house occupied by our party at Grand Marais, and frequently ventured *under* the building in their search for food.

39. [Chrysomitris tristis, (*Linn.*) *Bp.* Thistle Bird.—Found at Duluth in July, 1877.]

40. [Passerculus savanna, (*Wils.*) *Bp.* Savanna Sparrow.—Rather common about the fields below Duluth in July, '77.]

41. [Pooecetes gramineus, (*Gm.*) *Bd.* Grass Finch.—Common at Duluth, July, '77.]

42. [Melospiza palustris, (*Wils.*) *Bd.* Swamp Sparrow.—Duluth, common, July, '77.]

43. Melospiza meloda, (*Wils.*) Bd. Song Sparrow.—Abundant in every suitable locality. Minnesota Point, Sept. 1. Grand Marias, July 28; Aug. 13, etc.

44. [Junco hyemalis, (*Linn.*) *Scl.* Snow Bird.—Found common at Duluth in July, '77; but not noted at any point this summer.]

45. Spizella socialis, (*Wils.*) *Bp.* Chipping Sparrow.—A common species all along the shore and abundant at some more than usually suitable localities, as on Minnesota Point and about Grand Marais. Attending to young in early part of August. Grand Marais, Aug. 13.

46. Zonotrichia albicollis, (*Gm.*) *Bp.* White-throated Sparrow.—Common; rather shy; frequenting the thick brush and raspberry patches of burnt areas. A brood of young just able to fly and accompanied by the parent, was found at Grand Marais, Aug. 21. This, however, was exceptionally late. In song quite generally during the first week of August. From this time onward the singing gradually decreased until during the last week of the month it was only occasionally that the full song was heard.

47. Goniaphea ludoviciana, (*Linn.*) *Bowd.* Rose-breasted Grosbeak.—A single individual seen a short distance below Burlington Bay, Aug. 30.

48. [Cyanospiza cyanea, (*Linn.*) *Bd.* Indigo Bird.—Seen several times at Duluth, July, '77.]

49. Dolichonyx oryzivorus, (*Linn.*) *Sw.* Bobolink.—Heard flying over at Beaver Bay, Aug. 27, and [a male seen near Duluth, July 17, '77.]

50. Molothrus pecoris, (*Gm.*) *Sw.* Cow Blackbird.—A single specimen taken at Grand Marais, July 29. It was flying high in the air and alighted in the very top of a tall pine.

51. Agelæus phœniceus, (*Linn.*) *Vieill.* Red-winged Blackbird.—Small flocks of immature birds were seen occasionly. They must have been bred elsewhere, as this region is entirely unsuited to their nesting habits. First seen at Poplar River, Aug. 4-7; two taken at Grand Marais Aug. 19, and common at Beaver Bay, Aug. 26 29.

52. Quiscalus purpureus, (*Bart.*) *Licht.* Purple Grackle.—Noted but twice, once at Beaver Bay and once at Duluth.

53. Corvus corax, *Linn.* Raven.—Common. Residents say they are very numerous during the winter.

54. Corvus americanus, Aud. Crow.—Common at Duluth, Aug, 31—Sept. 2; but seen only occasionally further down the shore. Duluth, Sept. 1.

55. Cyanurus cristatus, (*Linn.*) *Sw.* Blue Jay.—Aparently uncommon. Seen near Cascade River, and again near Stewart River, and heard several times at Devil's Track Lake.

The Canada Jay (*Perisoreus canadensis*) is reported both by the white residents and the Indians, as common here, but none were seen by us.

56. Tyrannus carolinensis, (*Gm.*) *Temm.* King-bird.—Observed first at Grand Marais, Aug. 20, where two specimens were taken and several others seen. At Beaver Bay, but not common. [Common at Duluth in July, 1877.]

57. Sayornis fuscus, (*Gm.*) *Bd.* Phoebe Bird.—One taken at Grand Marais, Aug. 20, and a pair seen at Duluth, Aug. 31.

58. Contopus borealis, (*Sw.*) *Bd.* Olive-sided Flycatcher.—First seen Aug. 19 at Grand Marais. Five shot Aug. 20, when it was common on tops of talls trees in an old partial clearing. This species, together with the king-bird, appeared suddenly in a locality which had been under close inspection for some time previously.

59. Empidonax trailli, (*Aud.*) *Bd.* Traill's Flycatcher.—Taken at Beaver Bay, Aug. 27. [A female, whose actions seemed to indicate that it had young, was shot in a willow thicket at Duluth, July 13, '77.]

60. Empidonax minimus, *Bd.* Least Flycatcher.—Apparently common. Poplar River, Aug. 5. Grand Marais, Aug. 20.

61. Empidonax flaviventris, *Bd.* Yellow-bellied Flycatcher.—A pair taken at Poplar River, Aug. 6.

62. Chordeiles virginianus, (*Gm.*) *Bp.* Night Hawk.—Common in the latter part of August, when they were migrating in loose flocks.

63. Chetura pelagica,) *Linn.*) *Bd.* Chimney wift.—Generally distributed, but nowhere observed to be common, except at Duluth, in July, 1877. Aug. 5, a nest containing three young birds about two days old, was found in an abandoned house at Poplar River. The birds entered through a stovepipe hole in the roof, and had glued their nest to the vertical boards of one end of the attic. Seen at Devil's Track Lake, Aug. 16. It must breed almost exclusively in the hollow trees.

64. Trochilus colubris, *Linn.* Ruby-throated Humming-bird.—Taken at Grand Marais, July 29, and seen at Beaver Bay, Aug. 29.

65. Coccygus erythrophthalmus, (*Wils.*) *Bp.* Black-billed Cuchoo.—Grand Marais, Aug. 13 and 19. One seen at Beaver Bay, Aug. 27.

66. Picus villosus, *Linn.* Hairy Woodpecker.—Occasional. Grand Marais, Aug. 20.

67. Picus pubescens, *Linn.* Downy Woodpecker.—Rather common. Grand Marais, July 29.

68. Picoides arcticus, (*Sw.*) *Gray.* Arctic Woodpecker.—Taken at Grand Marais, Aug. 21, and seen at Black Point, Aug. 24. [Duluth, July 16, '77.]

69. [Melanerpes erythrocephalus, (*Linn.*) *Sw.* Red-headed Woodpecker. —A single individual seen at Duluth, July 11, '77.]

70. Colaptes auratus, (*Linn.*) *Sw.* Golden-winged Woodpecker.—Duluth, Sept. 1. Not noticed elsewhere; but its occurrence at Grand Marais during the migrations is reported by residents.

71. Bubo virginianus, (*Gm.*) *Bp.* Great Horned Owl.—Heard at night on several occasions, and a specimen secured at Grand Marais, Aug. 20.

72. Syrnium nebulosum, (*Forst.*) *Boie.* Barred Owl.—A medium sized owl, seen at Poplar River on the evening of Aug. 4, may have been this species.

73. [Accipiter fuscus, (*Gm.*) *Gray.* Sharp-shinned Hawk.—Seen at Duluth, July 16, '77.]

74. Astur atricapillus, (*Wils.*) *Jard.* American Goshawk.—A single (female?) bird of the year taken at Little Marais, on Aug. 26.

75. Falco communis, *Gm.* Peregrine Falcon.—At a point about two miles below Poplar Piver, where the shore of the lake is a rocky cliff surmounted by thick trees, a pair of these birds was seen Aug. 4. As we passed the place in a boat they circled about over the woods and water, uttering repeatedly short, harsh screams and seemed greatly agitated by our presence. Was it possible for them to have had young at that late date? Their actions certainly indicated that they had. A second pair, which, upon our intrusion upon their domain, acted in much the same excited manner, was seen Aug. 25 on the summit of Carlton's Peak, and a single individual was observed Aug. 24 about the high, jagged precipice of the "Saw-tooth" at Black Point.

76. Falco columbarius, *Linn.* Pigeon Hawk.—Taken at Grand Marais Aug. 13, and seen at Beaver Bay.

77. Falco sparverius, *Linn.* Sparrow Hawk.—Very common; especially numerous in burnt localities, where it perches on the dead trees. Feeds here largely on grasshoppers, as is its habit elsewhere.

78. Buteo pennsylvanicus, (*Wils.*) *Bp.* Broad-winged Hawk.—Grand Marais, Aug. 19, (young bird.)

79. Pandion haliaëtus, (*Linn.*) *Cuv.* Fish Hawk, Osprey.—Seen at Grand Marais, Poplar river and Duluth. These birds lived apparently in the range of hills back from the shore, and came to the lake at intervals to catch fish.

80. Aquila chrysaëtus, *Linn.* Golden Eagle.—A fine adult specimen, killed at Grand Marais in the fall of 1877, was presented to the survey this summer by Messrs. Thomas and Henry Mayhew, of Grand Marais.

81. Haliaëtus leucocephalus, (*Linn.*) *Sav.* Bald Eagle.—None seen, but a pair reported to have bred the present season at a point a number of miles inland from Grand Marais.

82. Cathartes aura, (*Linn.*) *Ill.* Turkey Buzzard.—A specimen procured by Prof. C. W. Hall, at Grand Marais, in Oct. 1878, is in the University Museum. Not noted this year.

83. Ectopistes migratoria, (*Linn.*) *Sw.* Wild Pigeon.—An occasional pair noted during the early part of August, and flocks of considerable size toward the last of the month. Grand Marais, Aug. 9.

84. Bonasa umbellus, (*Linn.*) *Steph.* Ruffed Grouse.—Several covies seen. In the middle of August the young were little more than half grown. Devil's Track Lake, Aug. 16.

85. [Ægialites vocifera, (*Linn.*) *Bp.* Killdeer Plover.—Noted at Duluth in July, '77.]

86. Lobipes hyperboreus, (*Linn.*) *Cuv.* Northern Phalarope.—A single female, taken Aug. 29, by Prof. N. H. Winchell, a few miles above Beaver bay. It was alone, swimming in the lake, at some distance from the shore.

87. Ereuntes pusillus, (*Linn.*) *Cass.* Semipalmated Sandpiper.—Mouth of Devil's Track river, Aug. 21.

88. Tringa Minutilla, *Vieill.* Least Sandpiper.—Common; frequenting in place of the unsuitable shingle beaches, the perfectly bare and smooth rocky shore.

89. Tringa bairdii, *Coues.* Baird's Sandpiper.—Two specimens taken at Grand Marais, Aug. 22. Together with one or two others of the species and several Least Sandpipers, they were feeding on the wet rocks, seeming to find abundant food in the path of every retreating wave.

90. Tringa alpina americana, *Cass.* Black-bellied Sandpiper.—A single individual seen on Aug. 30, near Agate bay.

91. Totanus flavipes, (*Gm.*) *Vieill.* Lesser Telltale.—Common; in small flocks on the beaches. Grand Marais, July 28.

92. Totanus solitarius, (*Wils.*) *Aud.* Solitary Sandpiper.—Rather common. A small shallow pond, full of fallen trees and brush, was their favorite resort at Grand Marais. Grand Marais, July 29.

93. Tringoides macularius, (*Linn.*) *Gray.* Spotted Sandpiper.—Common. Seen at Devil's Track Lake, Aug. 18. Duluth, Sept. 1.

94. [Botaurus Minor, (*Gm.*) *Boie.* American Bittern. Seen at Duluth in July, '77,] and heard of at Grand Marais this year.

95. Porzana carolina, (*Linn.*) *Cab.* Carolina Rail.—Common, though the almost entire absence of marshes forces the species to frequent what seem very unsuitable places. For instance, the dense raspberry patches of burnt sections, thick brush, a pea patch, the rank grass about abandoned habitations, and like curious localities. Once I found three quietly reposing several feet from the ground in an evergreen tree standing in a perfectly dry, stoney location; and on another occasion shot a specimen from the smaller branches of a tree, where it had alighted upon being flushed from a weed-patch on a dry hill side. Grand Marais, Aug. 20. Poplar River, Aug. 5. Beaver Bay, Aug. 27.

97. Anas boschas, *Linn.* Mallard.—Mouth of Devil's Track River, Aug. 20.

98. Querquedula discors, (*Linn.*) *Steph.* Blue-winged Teal.—Two seen in Grand Marais harbor, Aug. 22.

99. [Aix sponsa, (*Linn.*) *Boie.* Wood Duck.—Flock of six seen in Superior Bay, Duluth, July 13, '77.]

100. Mergus merganser, *Linn.* Goosander.—Apparently common. A large brood seen several times on Devil's Track Lake. When alarmed they fluttered along over the surface of the water for a long distance, uttering loud cries. They retreated occasionally down the river and probably came up to the lake for the purpose of fishing. (Possibly *serrator*, as no specimen was secured.)

101. Mergus cucullatus, *Linn.* Hooded Merganser.—A single female seen at Grand Marais, July 28.

102. Larus argentatus, *Brünn.* Herring Gull.—Abundant. They are said to breed on two small rocky islands near Grand Marais. Stomach of one specimen found full of grasshoppers which it had probably picked up from the surface of the water for these insects perish in the lake in countless numbers. Grand Marais, Aug. 12.

103. Larus delawarensis, *Ord.* Ring-billed Gull.—Common. Grand Marais, Aug. 19.

104. Colymbus torquatus, *Brünn.* Loon.—Common.

105. Podilymbus podiceps (*Linn.*) *Lawr.* Pied-billed Grebe.—A specimen taken by Prof. Hall in the fall of 1878. A species of grebe, probably *P. podiceps*, was occasionally seen on the lake the present season.

T. S. ROBERTS.

MINNEAPOLIS, MINN., Dec., 1879.

# APPENDIX A.

[FROM THE AMERICAN JOURNAL OF SCIENCE, VOL. XIX, FEBRUARY, 1880.]

## *On Lintonite and other forms of Thomsonite: A preliminary notice of the Zeolites of the vicinity of Grand Marais, Cook County, Minnesota;*

BY S. F. PECKHAM AND C. W. HALL.

Grand Marais is situated on the northwest coast of Lake Superior, one hundred and eight miles northeast of Duluth. It is the site of an early French trading or mission station, and was later a station of the Hudson Bay Company. Its beautiful land-locked bay furnishes the only good harbor between Duluth and Pigeon Point.

The rocks, for several miles east and west, as well as at the Marais, are classed in general as igneous, and have often a basaltic structure. They present, however, great diversities of character both to the chemist and lithologist; and while the mineral species are perhaps altogether old, the forms are in some cases new. It was our original intention to confine this research to one or two peculiar forms that first attracted our attention, but in the progress of our examination the subject has outgrown its earlier proportions, both as regards its extent and the time required for its successful completion. We have therefore concluded to give in the present paper some general observations with such details as are at present in hand, reserving others until further study and analyses shall have rendered the work more complete.

At Good Harbor Bay, about four miles to the westward of Grand Marais, there begins a bed of dark colored rock, highly decomposed at surface, and related to diabase in its lithological characters. This bed extends westward along the coast for several miles, sloping gently from the wooded hilltops a mile or two inland, and disappearing beneath the waters of the lake In its fresher parts the rock is somewhat mottled where coarsest, and nearly black with a greenish tinge where finest in texture. It is only from the talus, under the wall of rock rising above an underlying sandstone outcrop in Good Harbor Bay, that this fresh material can be easily obtained. Even here the mottled appearance discloses the partial decomposition of the most perishable of the constituents, and the formation of some new viriditic mineral. The lower layers are firm and compact, while the upper are extensively jointed and fractured, and filled with amygdaloidal cavities, These cavities, in whatever manner they were originally formed, have

become filled with zeolitic minerals. Some of the cavities are now empty, but evidently as a result of the removal of their contents by solvents percolating through the enclosing rock. Occasionally the cavities are only partially filled, and the substance within shows on its surface unmistakable traces of the action of solvents. In some cavities one mineral is nearly all washed away, leaving the surface of the remaining one or several, as the case may be, rough or uneven, as originally formed. This occurs only where water has had access.

The prevailing mineral, thomsonite, is only sparsely distributed in the lower and compacter beds of the formation. The general occurrence of the several other minerals, so abundant here, would seem to indicate that this mineral was formed first of all from the decomposition of the rock, and that one of the others owes its origin in part at least to the decomposition of those that were formed before it. In many masses of the rock where much exposed and weathered the matrix has been so decomposed as to be easily broken away from the amygdules, but in the fresher portions the fractures extend across them. The other zeolites, being less persistent than the thomsonite, rapidly disappear, while the amygdules of this mineral remain upon the narrow beaches of this vicinity in the form of pebbles of various sizes, frequently unbroken and beautifully polished.

The cavities containing thomsonite are in many places exceedingly numerous, and in other cases few in number, even in the same bed of rock. The size varies from a microscopic point to a diameter of two or three inches. In one piece of the thomsonite-bearing rock, now in the General Museum of the University of Minnesota, the number of amygdules distinctly visible to the unaided eye on a surface two inches square is sufficient to give more than 10,000,000 to the cubic foot. The largest in this area was about half an inch in diameter. The amygdules are generally much larger and more scattered than this specimen would indicate. Since they abound in the rock throughout many feet of its thickness and many miles of its extent along the shore, the supply appears to be inexhaustible; but practically the number of beach-pebbles, valuable as specimens, is quite limited. All the different varieties of thomsonite are so hard that they take a fine polish; and on account of this property and their often unique banded structure, they are much sought after by tourists and others as objects of rare beauty, and also for buttons, studs, etc.

On our first visit to the beach where the greater number of these pebbles occur, we at once recognized fragments of the large amygdules as thomsonite. Intermingled with these were spherical and oval pebbles, often more or less flattened, and of all sizes from that of a pin's head to that of a hickory nut, but for the most part of the size and form of beans and peas. Some of these were also recognized as thomsonite. The larger portion presented a great diversity of color and physical structure; some being white and opaque, almost conchoidal in fracture, with but slight indications of a fibrous structure; others flesh-colored throughout, hard and fibrous, resembling thomsonite from the Tyrol and other localities except in their greater hardness and finer texture; others coarser, closely resembling the mineral from other localities; others, curiously banded externally with zones and annular spaces of red, green, pink and white; and still others, opaque and chrome-green in color, shading out in some to colorless and

translucent with a conchoidal or uneven fracture. These last were at first supposed to be fragments of prehnite, rounded by attrition. On further examination a number of the green pebbles were found to have a fibrous and flesh-colored interior with a shell of the amorphous green mineral. In given portions of the rock formation, the amygdules were, for the most part, of the same general character; in one place, being green and opaque; in another, without green bands; while in another, for the most part, beautifully variegated. Similar local peculiarities were observed in reference to texture, some portions of the rock containing only those that were hard and fine grained, while others those that were uniformly coarser in texture.

In our examinations of the amygdules, we designated the opaque white variety, Number *one* (I), the ordinary thomsonite, Number *two* (II), and the *green* varieties, Number *three* (III).

As regards hardness, the thomsonite—in nearly all its varieties—is peculiar. Some fibers scratch quartz, which indicates a hardness above 7; but this may be owing to the presence of free silica. The harder specimens of Nunber III scratched an agate mortar easily, but were scratched by quartz crystal; yet the percentage of silica was found to be no higher in the harder than the other specimens. The grain of such specimens, however, is exceedingly fine. Most frequently the hardness is between 5 and 6. The specific gravity varies from 2.33 to 2.35; the water-worn and somewhat weathered pebbles have it a little lower, one or two as low as 2.2. The fracture of Numbers I and II is fibrous; of Number III very uneven, and takes place in all directions with almost equal facility. They all gelatinize in hydrochloric acid to a thick jelly. Before the blowpipe they fuse easily and intumesce to a porous white enamel. In the closed tube, water to the amount of 11 to 12 per cent. of the whole weight was given off at the heat of an ordinary spirit lamp. Grains of native copper are frequently found in them, particularly in those of Number III, which, if the pebbles are transparent, exhibit under a low magnifying power arborescent groups of crystals, thrusting out their branches in every direction through the enclosing mineral. In one instance an amygdule, about as large as a cranberry, contained at its center a mass of copper of this kind, one-third of its diameter. In this characteristic Number III resembles the prehnite of French River.

*Number I.*—The amygdules of this type are perhaps of less common occurrence than other forms. Externally they look like porcelain with a slight creamy tint. Under the microscope they appear for the most part translucent. Countless fine dark lines extend longitudinally through the thin section, rapidly disappearing to be replaced by others, like the cells in a longitudinal section of wood, which are probably caused in part by refraction of the light from the edges of minute densely packed crystals, from cavities, and from microlites. One noticeable result of these lines is to weaken the effect of the mineral on polarized light. Not infrequently this opaque modification of the mineral is banded with alternating zones, either transparent or yellow, or even with both; the transparency here seems to be owing to an absence of the lines and microlites just noticed; while the yellow zones owe their color to globules of ferric oxide distributed through the mass. In the worn amygdules the mineral often has a beautiful pearly

lustre. In minute quantities the ferric oxide gives the mineral a flesh-colored tint.

A mean of three analyses showed the composition of this mineral to be:

| | |
|---|---|
| $SiO_2$ | 40.45 |
| $Al_2O_3$ | 29.50 |
| $Fe_2O_3$ | 0.232 |
| CaO | 10.75 |
| $K_2O$ | 0 357 |
| $Na_2O$ | 4.766 |
| $H_2O$ | 13.93 |
| | 99.985 |

Even opaque *white* amygdules afforded a trace of ferric oxide, which increased to a few hundredths of one per cent. when the tint was perceptibly flesh-red.

*Number II.*—Under this type nearly every specimen is fibrous and radiated. The masses are spherical or elliptical, with the point from which the crystalline fibers radiate on one side of the mass, or, as is perhaps more common, having several centers of radiation within the compact mass. Occasionally the mineral fills seams, or occupies cavities that run together; here, there are centers of radiation at frequent intervals and by a system of suture-like joints, the whole is made into a compact mass. Yet, solid as the mass may appear to be, a thin plate cut from it invariably separates into pieces along the line of these joints, giving the mineral an appearance of fragility while it is really as hard as agate. The fibers often interlock along the line of these joints.

At the outer extremity of many of these radiated concretions, there often occur many transparent needles, large enough to be seen with the unaided eye, extending backward along the direction of the fibers toward the center of radiation. These needles are broken up into short pieces by transverse fractures. They all taper out and disappear, the longest of them reaching no further than the middle of the mass. They act strongly on polarized light and contain some inclusions. These lines do not occur as developed crystals.

Around the borders of many amygdules there are numerous small sphærolites. They have probably formed around granules of various foreign substances as nuclei. Their size is small; to the naked eye they look like mere spots, but they are so numerous as to form an envelop almost entirely around the radiated concretions.

A mean of three analyses gave—

| | |
|---|---|
| $SiO_2$ | 46.020 |
| $Al_2O_3$ | 26.717 |
| $Fe_2O_3$ | 0.813 |
| CaO | 9.400 |
| $K_2O$ | 0.390 |
| $Na_2O$ | 3.756 |
| $H_2O$ | 12.800 |
| | 99.896 |

*Number III.*—As before stated, these pebbles, when first seen, were supposed by us to be worn fragments of reniform prehnite, so common in several localities along this shore. We soon found evidence that they were amygdules; still the fact that they were not prehnite was not suspected until their specific gravity had been determined and found to be that of thomsonite, 2.32 to 2.37. Analysis showed them to contain—

| | |
|---|---|
| $SiO_2$ | 40.605 |
| $Al_2O_3$ | 30.215 |
| FeO | .40 |
| CaO | 10.370 |
| $K_2O$ | .49 |
| $Na_2O$ | 4.055 |
| $H_2O$ | 13.75 |
| | 99.885 |

This composition allies the mineral very closely to thomsonite, so closely that, considered alone, there appears little reason why the mineral should not be considered as a variety; but there are several notable reasons why a specific name may properly be applied to this, as we believe, hitherto undescribed mineral.

These pebbles are wholly destitute of the radiated and crystalline character of other forms of thomsonite. Under the microscope the texture is wholly granular so that the crystalline system cannot be determined; and the granules are so fine and so compactly arranged in many specimens that they can be resolved only in polarized light. Their size, however, is not uniform in the same pebble, being so fine in some places that only a high power will make them visible.

Sphærolites are also frequent; but unlike their mode of occurrence in the thomsonites, they are distributed almost at random in any part of the amygdules containing them; and frequently some foreign material, as a bit of copper, is a nucleus. The sphærolites often occur in groups; large numbers are crowded and heaped together, growing into and overlapping one another, like the tridymite scales in the rhyolites of Mexico and the trachytes of the Siebengebirge. These groupings are not always spherical; sometimes they extend in long curving lines through the mass, following perhaps a fracture or a seam, instead of being collected around a nucleus as a sphærolite. They show parallel green fibers meeting along a median suture and correspond in their manner of occurrence to Zirkel's description of axiolites in the rhyolites of the 40th parallel.*

The amygdules of the green variety rarely exceed in size a small hickory nut. As before stated, they are not generally found intermingled in the rock with the other forms, but have special localities—they filling nearly all the amygdaloidal cavities within a given limit, whose boundary at the same time is not sharply defined. Frequently the forms of No. I or II are enveloped in a green covering of considerable thickness. Moreover, the amygdules of this type uniformly contain ferrous oxide in small but varying proportion in combination, whereas in Numbers I and II the microscopic

* U. S. Geol. Explor. 40th Parallel, vol. vi, p. 166 et seq.

sections show the ferric oxide to be segregated in minute particles or patches mechanically distributed through the fibrous mass; and in many amygdules these particles can be seen distinctly even with the unaided eye. Nor can Numbers I and II be considered as altered forms of Number III, as the condition of the iron might indicate. No amygdule has come under our observation which exhibited a nucleus of Number III, surrounded by Number I or II. On the contrary, we have quite a number in which, through a thin translucent shell of Number III, the pink interior can be discerned. And we also have fragments, and amygdules have been cut, which show the external crust of Number III passing toward the center into the radiated form of Number II.

In determining the oxygen ratio for Number II, the silica appeared to be too high. We had previously suspected the presence of free silica from the exceptional hardness of all of these varieties. As the microscope showed the ferric oxide in every case to be free, we concluded to compute the percentages for Number II to 40.45 per cent. of silica, the amount found in Number I, and exclude the iron oxides. We were much surprised at the results, which are given below:

| | I. | II. | | III. |
|---|---|---|---|---|
| $SiO_2$ | 40.45 | 40.45 | | 40.605 |
| $Al_2O_3$ | 29.50 | 29.37 | | 30.215 |
| $CaO$ | 10.75 | 10.43 | | 10.37 |
| $K_2O$ | 0.36 | 0.42 | | 0.49 |
| $Na_2O$ | 4.76 | 4.28 | | 4.05 |
| $H_2O$ | 13.93 | 13.93 | | 13.75 |
| | 99.75 | 98.88 | | 99.48 |
| $Fe_2O_3$ | 0.23 | 0.88 | $FeO$ | .40 |
| | 99.98 pr. ct. | 99.76 pr. ct. | | 99.88 pr. ct. |

These figures prove conclusively that we were dealing with varieties of the same mineral. On comparing these percentages with those given in Dana,* the water and silica were found to be high.

Computing the oxygen ratios and formula for Number III, we have

| | Per cent. | Metal. | Oxygen. | Atoms. |
|---|---|---|---|---|
| $FeO$ | 0·40 | 0·3111 | 0·0889 | ·0064 |
| $K_2O$ | 0·49 | 0·4068 | 0.0832 | ·0052 |
| $Na_2O$ | 4·055 | 3·0118 | 1·0432 | ·0654 |
| $CaO$ | 10·37 | 7·4070 | 2·9630 | ·1852 |
| | | | 4·1783 R. | ·2622 |
| $Al_2O_3$ | 30·215 | 16·1343 | 14·0807 | ·2933 |
| $SiO_2$ | 40·605 | 18·949 | 21·656 | ·676 |
| $H_2O$ | 13·75 | 1.528 | 12.222 | ·765 |

Dividing the oxygen percentages by 5, we have

$$RO : R_2O_3 : SiO_2 : H_2O = 1 : 3 : 4 : 2\tfrac{1}{2},$$

which is the ratio for thomsonite, given in Dana's Mineralogy, with the

* System of Mineralogy, fifth edition, p. 425.

bases low and the silica and water high. Dividing the atoms by ·005, we have the formula

$$(2\text{·}5(FeO+K_2O+Na_2O)+3\text{·}5CaO)Al_2O_3\ ,\ (SiO_2)_3\ (H_2O)_3\ ,$$

with the protoxide bases low, and the silica and water high.*

Computing the ratios after Rammelsberg) we have:

$(Na+K):(Ca+Fe)::1:1·35$
$(Ca+Fe):Al_2::1:1·54$
$(Ca+Fe+K+Na)=R:Al_2:Si::1·13:1:2·03$
$Si:H::1:2·26$

Rammelsberg deduces from these ratios a formula which he calls a half silicate (Halbsilicat), according to the expression

$$\left\{\begin{matrix} m\,(2Ca\ \ Al_2\,Si_2\,O_8+5aq) \\ n\,(2Na_2\,Al_2\,Si_2\,O_8+5aq) \end{matrix}\right\}\dagger$$

in which $m$ indicates a certain proportion of a hydrous silicate of aluminum and a dyad protoxide, and $n$ a certain proportion of a hydrous silicate of aluminum and an alkaline or monad protoxide. The ratio between $m$ and $n$ varies in different specimens. Number I and Number II, without the excess of silica, approach more nearly the thomsonite of Elbogen in composition (in which the ratio of $m$ to $n=2:1$) than any mentioned by Rammelsberg. While the ratio of Si to H is about the same as given by Rammelsberg, the percentage of both in these specimens is higher than in the analyses quoted by him.

We conclude, therefore, that this mineral contains a small percentage of free silica, and also that a part of the water is basic. This latter opinion is strengthened by the fact that about 12 per cent. of the water escaped at a dull red heat, and that only prolonged heating in a platinum crucible for several hours would expel the last 1·75 per cent. At least six determinations of the water were made in this variety, with the same result.

The percentages of Numbers I and II are so near that of Number III that no material difference can exist in their formulæ. While recognizing this fact as respects the chemical constitution of these minerals, the great difference in their physical structure leads us to regard Number III as a distinct and well marked variety of thomsonite, if not a distinct species. We have therefore given it the name *Lintonite*, in honor of Miss Laura A. Linton, a recent student and graduate of this University, to whose patient effort and skill we are indebted for the analyses given in this paper.

UNIVERSITY OF MINNESOTA, Nov. 20, 1879.

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* Fifth edition, p. 425.

† Rammelsberg Min. Chem., Ed. 1875, p. 637.

# APPENDIX B.

## CORRESPONDENCE WITH THE UNITED STATES GEOLOGICAL SURVEY.

[Telegram.]

WASHINGTON, Feb. 28, 1880.

*Prof. N. H. Winchell, State Geologist, Minneapolis:*

During the coming spring it is probable that congress will determine the question whether or not the surveys shall be extended over the whole area of the United States. It is not the policy of this organization to make surveys of States, but simply to follow such general questions as happen at any time to be under investigation wherever the facts may lead, regardless of political lines. An erroneous impression of the policy of this bureau having been industriously circulated, the director desires to announce to you that he urges the inauguration and continuance of State surveys, and wishes to co-operate with them, to the mutual advantage of both parties. He desires to ask whether or no, in your opinion, such general extension of this survey is desirable to meet the practical and scientific needs of the people and the Government, and whether you would wish to co-operate with him. Please reply very fully by telegraph.

CLARENCE KING.

[Telegram.]

THE UNIVERSITY OF MINNESOTA,
MINNEAPOLIS, MINN., Mar. 1, 1880.

*Clarence King, Director of the United States Geological Survey, Washington, D. C.:*

The general extension of the United States Geological Survey over the whole area of the United States is, in my opinion, desirable for the following reasons:

1. It will give it full data for the discussion of questions that arise in one part and cannot be settled without examinations in other parts.

2. The need of geological science in America is a systematic and authorized adjustment of a great many questions that have been variously

answered by the various local geologists of the States, principally because of restricted areas of examination. Such an extension of the United States Geological Survey would ultimately harmonize a great many apparent discordances that now exist, and would redound to the advancement of the science, and the general acceptance of its truths among the people.

3. There are some States, as well as Territories that never have completed geological surveys, and perhaps never will. Yet a knowledge of this geology is essential to the interpretation of the geology of adjoining States, particularly when they isolate those adjoining States from the before-surveyed areas of the Union. There should be some agency for surveying such areas of the Union. The geological relationships between the States is as intimate as the hydrographic, or the climatic, or the sanitary, or the commercial; and the general "practical and scientific needs of the people" just as much require their examination, interpretation and full publication.

4. I have no sympathy whatever with the alarming cry of *States rights*, as against such a general extension of the United States Geological Survey. The history of the past century has sufficiently established the national character of the United States. It is pre-eminently a nation's duty to survey and map, and develop its domain, whether held by private parties or not; and our Government has recognized this duty in a great many ways. It has established hydrographic, magnetic, geoditic, climatic, ethnologic, astronomic, topographic and other surveys and investigations of a national character, in one way and another, which are as likely to trespass on the rights reserved to the States as anything connected with a geological survey.

5. The older States that have been surveyed, ought to be re-surveyed. The development of the country is so rapid that new geologic facts are constantly being exposed, bearing on a knowledge of the strata and their contents. This is in the nature of science. It is no fault of the early geologists. This necessity is so apparent that in several of the older States such re-surveys have already been undertaken.

6. The aggregate cost to the United States of a uniform general survey, of the character and completeness that the United States government would execute, would certainly be much less, and the survey would be much quicker done than if each State should institute its own survey and invest in apparatus and outfit and carry it on independently.

*On the other hand*, the general extension of the United States Geological Survey over the whole area of the United States, would result disastrously in the following ways, unless special provision be made against them:

1. Reducing the number of scientific investigators and observers, by the absorption of their functions and duties into the general United States Survey, and hence the decadence of general popular knowledge of, and interest in, scientific matters.

2. The removal of specimens and material for museums from the States to the national capital, and hence the injury of the States themselves by compelling the citizen to travel often a great distance to examine his home products.

3. In an educational sense, the loss to the State of those incentives, methods and means of scientific knowledge which are derived from the geological examination of the State.

4. The interference with, and final termination of, the present and the prevention of future State geological surveys.

If a law can be framed that will carry out the former considerations, but guard against the latter, I should be in favor of it, and should be glad to co-operate with such a United States Geological Survey.

The mere extension of the present U. S. Geological Survey, for the purpose of certain economical investigations over the whole area of the United States, is not only very desirable, but almost necessary for the satisfactory elucidation of our national material wealth, making a kind of geological census; and I shall be glad to co-operate in every way in my power. It seems to me that a law could be framed that would allow the States, through their State Universities, a large latitude in the control of the material gathered, and in the educational interests involved, but which would still place the general supervision, direction and publication at Washington.

Yours very respectfully,

N. H. WINCHELL.

# APPENDIX C.

[EXTRACTED FROM THE AM. JOUR. OF SCIENCE AND ARTS FOR JUNE, 1880.]

## *Study of the Emmet County Meteorite, that fell near Estherville, Emmet County, Iowa, May* 10, 1879.

BY J. LAWRENCE SMITH, LOUISVILLE, KY.

The fall of this meteorite is in all its attendant circumstances one of the most remarkable on record. I therefore visited the region, on my return to America some months after its fall, and saw the two large masses which are the main representatives. Several short notices have already appeared on the subject; among them, one each, by Professor Shepard, Professor Peckham and Professor Hinrichs; and in describing the physical and chemical characteristics of the original masses, I shall be obliged to repeat some details that have been brought out.

*Locality.*—The place of fall is near Estherville, Emmet County, Iowa, just on the boundary of the State of Minnesota, lat. 43° 30′, lon, 94° 50′, within that region of the United States which has become remarkable for falls of meteorites, and of which I gave an outline map in my article on "the three meteorites that fell at Rochester in Indiana, Cynthiana in Kentucky, and Warrington in Missouri, within the space of one month."*

The State of Iowa has become particularly conspicuous in recent years as the landing place of these celestial messengers; and I now have under examination still another remarkable one with some peculiar physical characters, but about which I have not yet obtained the historic details.

The *phenomena accompanying the fall* were of the usual character, but on a grander scale. It occurred about five o'clock in the afternoon, under a clear sky, with the sun shining brightly. In some places the meteorite was plainly visible in its passage through the air, and looked like a ball of fire with a long train of vapor or cloud of fire behind it, and one observer saw it 100 miles from where it fell. Its course was from northwest to southeast. The sounds produced in its course are referred to as being "terrible" and "indescribable," as scaring cattle and terrifying the people over an area many miles in diameter. At first they were louder than that of the largest artillery; these were followed by a rumbling noise, as of a train of cars crossing a bridge. The concussion when it struck the ground was sensible

*Am. Journal of Sci. and Arts, Vol. XIV, 1877.

to many persons, and it is reported that the soil was thrown into the air at the edge of a ravine where the largest of the masses was found. Two individuals were within two or three hundred yards of the spots where the two larger masses fell.

There were distinctly two explosions. The first took place at a considerable height in the atmosphere, and several large fragments were projected to different points over an area of four square miles, the largest mass going farthest to the east. Another explosion occurred just before reaching the ground, and this accounts for the small fragments found near the largest mass.

*Impact with the earth.*—A remarkable fact connected with the fall, besides that of the local disturbance of the earth alluded to, is the depth to which the mass penetrated. Had the fall taken place during the night, I doubt if the largest fragment would have been found. It struck within 200 feet of a dwelling house, at a spot where there was a hole (previously made) six feet deep and over twelve feet in diameter, filled with water, and having a bottom of stiff clay. This clay was excavated to a depth of eight feet before the meteorite was discovered, and two or three days elapsed before it was reached. Its total depth below the general surface of the ground was hence fourteen feet.

The second large mass was found embedded in blue clay about five feet below the surface, at a place two miles distant from the first. The third of the three largest masses was not discovered until the 23d of February, 1880, more than nine months after the fall, and its locality was four miles from the first. A trapper on the prairies, who had witnessed the original occurrence, observed a hole in a dried-up slough; on sounding it with his rat spear, he detected a hard body at the bottom, and on digging found the stone at a depth of five feet. Some small fragments were doubtless detached when the large mass approached the ground, as they were discovered near to it. The fragments thus far obtained weighed respectively, 437, 170, 92½, 28, 10½, 4 and 2 pounds.

*Height and velocity.*—A railroad engineer who observed it before the report, estimated its height to be forty miles, but at the time of the explosion much less; from an imperfect computation, he considered its velocity to be from two to four miles per second.

*External Characters.*—The masses are rough and knotted like large mulberry calculi, with rounded protuberances projecting from the surface on every side: the black coating is not uniform, being most marked between the projections. These projections have sometimes a bright metallic surface, showing them to consist of nodules of iron; and they also contain large lumps of an olive-green mineral, having a distinct and easy cleavage, which is more distinct where the surface has been broken. The greater portion of the stony material is of a gray color, with this green mineral irregularly disseminated through it. The two minerals are mixed under various forms; sometimes the green mineral is in small rounded particles intimately mingled with the gray, at other times it is in small cavities in minute crystalline fragments, without any distinct faces, and almost colorless. The masses are quite heavy and vary much in specific gravity in their different parts; but the average cannot be less than 4.5. When broken, one is immediately struck with the large *nodules* of metal among the gray

and green stony substances, some of which will weigh 100 grams or more. In this respect this meteorite is unique, it differing entirely from the mixed meteorites of Pallas, Atacama, etc., or the known meteoric stones rich in iron; for in none of these has the iron this nodular character.

Another striking feature in the relation of the iron and stony matter is, that the larger nodules of iron appear to have shrunk away from the matrix; an elongated fissure of from one to three millimeters sometimes intervening, separating the matrix and nodules to the extent of one-half the circumference of the latter, and appearing as if the iron had contracted from the stony matrix during the process of cooling. There are numerous small cavities of various sizes, where there are not any iron nodules, and where the minerals appear more crystalline, indicating an irregular shrinkage during the consolidation.

*The minerals.*—At first sight I expected to find more than two earthy minerals. The microscope gave, as with most meteoric stones, unsatisfactory results. I therefore tried to separate the stony minerals mechanically; the only mineral that I was enabled to obtain pure in sufficient quantity, has an olive green color, and occurs in masses of from one-half to one inch in size, having an easy cleavage, especially in one direction; this is proved to be *olivine.* The same mineral occurs also in minute rounded concretions in other parts of the meteorite; and minute, almost colorless crystalline particles in the cavities I take to be olivine. *Nickeliferous* iron, as already stated, is very abundant. *Troilite* exists in small quantity. *Chromite* was also found.

That the stony part of this meteorite consists essentially of bronzite and olivine will be seen from the chemical investigation, which found only three essential constituents, viz: silica, ferrous oxides and magnesia. Another silicate will be referred to beyond, consisting of the same oxides, but in different proportions from either bronzite or olivine.

*Chemical constitution.*—The stony part, pulverized and freed as far as possible from metallic iron by the aid of the magnet, when treated with chlorhydric acid on a water bath for several hours, is resolved into soluble and insoluble parts, the proportions varying very much with different fragments, and ranging from 16 to 60 per cent for the soluble part. This soluble part consists of silica, ferrous oxide and magnesia, and without a trace of lime, thus indicating the absence of anorthite.

(1) *Insoluble portion.*—The insoluble portion was carefully analyzed by fusion with carbonate of soda, and found to contain:

| | | Oxygen ratio. |
|---|---|---|
| Silica | 54·12 | 29·12 |
| Ferrous oxide | 21·05 | 4·67 |
| Chromic oxide | trace. | |
| Magnesia | 24·50 | 9·80 |
| Soda with traces of potash and lithia | ·09 | ·023 |
| Alumina | ·03 | ·013 |
| | 99·29 | |

The oxygen ratio clearly indicates the mineral to be $\ddot{\mathrm{Si}}\dot{\mathrm{R}}$, being virtually $\ddot{\mathrm{Si}}$ ($\dot{\mathrm{Mg}}\dot{\mathrm{Fe}}$), or the common form of *bronzite* contained in meteorites.

(2) *Soluble portion.*—On testing the green mineral already referred to I found that this was the soluble portion, and it was readily detected in a pure state from the stony part of the meteorite. Its cleavage in one direction is very perfect; its specific gravity 3·35; hardness almost 7; pulverized, it is readily and completely decomposed by hydrochloric acid. Two analyses were made, one by decomposing it directly with hydrochloric acid over a water bath, and the other by first fusing it with carbonate o soda—the two analyses agreeing perfectly.

| | | Oxygen ratio. |
|---|---|---|
| Silica | 41·50 | 22·13 |
| Ferrous oxide | 14·21 | 3·12 |
| Magnesia | 44·64 | 17·86 |
| | 100·35 | |

The above analysis gives the formula $\ddot{Si}\dot{R}_2$, or that of olivine.

(3) *Opalescent silicate.*—In some parts of this meteorite, a silicate occurs that is opalescent, of a light greenish-yellow color, and cleaves readily. In one instance I observed it making a notable projection on the surface. Although I had a number of fragments of the meteorite for examination, amounting to ten or twelve pounds, I did not obtain enough of the mineral to establish positively its true character, but I hope to obtain more. An analysis was made with about 100 milligrams of the pure mineral with the following result:

| | | Oxygen ratio. |
|---|---|---|
| Silica | 49·60 | 26·12 |
| Ferrous oxine | 15·78 | 3·50 |
| Magnesia | 33·01 | 13·21 |
| | 98·39 | |

Equivalent to $\ddot{Si}\dot{R}_2 + \ddot{Si}_2\dot{R}$, one atom of bronzite plus one atom of olivine, a form of silicate that we might expect to find in meteorites.

(4) *The nickeliferous iron.*—As already stated this iron is abundant in the meteorite, and sometimes in large nodules of 50 to 100 grams; on a polished surface the Widmanstättian figures are beautifully developed by acid. On analysis it was found to contain:

| | |
|---|---|
| Iron | 92·001 |
| Nickel | 7·100 |
| Cobalt | ·690 |
| Copper | minute quantity. |
| Phosphorus | ·112 |
| | 99·903 |

(5) *Troilite.*—The proportion of troilite is not large, and it could be detached only in small fragments.

(6) *Chromite.*—When small pulverulent fragments of the meteorite are heated with hydrochloric acid for some time and the residual matter washed and dried, it is easy to find particles of the stony mineral more or less filled with minute black shining particles which are chromite.

The constitution of this meteorite, so far as I have been able to make it out, is therefore as follows:

*Bronzite*, abundant; *olivine*, abundant; *nickeliferous iron*, abundant; *troilite*, in moderate quantity; *chromite*, in minute quantity; *silicate*, not yet well determined.

It will be thus seen that in its composition the meteorite contains nothing that is peculiar. I should, however, give it a unique position among meteorites, on account of the phenomena accompanying its fall, especially the great depth to which it penetrated beneath the surface, and also because of its physical characters and the manner of association of its mineral constituents. I examined carefully for feldspar and schreibersite; but the absence of both lime and alumina (except as a trace) clearly proved the absence of anorthite; and the small particles of the mineral that might have been taken for schreibersite were found on examination in all instances to be troilite.

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*Emmet County Meteorite*:—When my paper was sent to press, the following new facts in connection with this meteoritic fall had not been discovered. I am indebted for them to Mr. Chas. Birge. These additional discoveries, twelve months after the fall, only add to the interest of this phenomenon. Mr. Birge, a few months ago, had been made aware of the fact that a number of boys, herding cattle near a lake about four miles west of Estherville on the day of the fall, reported that when the meteor passed over them, a great shower of what appeared to them hailstones fell, and that the surface of the water was alive with the falling bodies. Three weeks ago (April 15th) the people of that heighborhood began to find, on the freshly burnt prairies, small pieces of meteorites from the size of a pea to one pound in weight; 300 to 500 were thus found; and ten days ago (May 1st) thousands of men, women and children were on the ground daily, and from the meteoric field probably five thousand pieces have already been gathered, making in all a weight of not less than from 60 to 75 pounds.

# APPENDIX D.

## CASTOROIDES OHIOENSIS, *Foster*.

BY N. H. WINCHELL.

In the city of Minneapolis, while digging for a cistern on the corner of Washington avenue and Fifteenth avenue north, Mr. — Sommers discovered, at the depth of eight feet, the left mandibular ramus of this rare beaver-like rodent. The position is within the Valley of the Mississippi River, and under the sandy loam that lies on the brick clay. Referring to the diagram opposite page 168 of the report for 1876 (fifth report), its position is illustrated. It lay near the bottom of the "sandy, loam-covered, gravelly plain," about twenty feet above the river, and over the brick clay, so near the brick clay that in excavating in search for other pieces, some of the clay was thrown out. Accompanying it were fragments of *Unio* shells. It hence belongs to that period of time when the Mississippi extended between the high drift bluffs that enclose the city of Minneapolis, and which are about two miles apart, and hence to the flood, or "terrace," epoch, of the glacial period. Probably the ice of the glacial period still prevailed over the northern part of the State, its dissolution supplying the abundant water which kept the Mississippi at that stage.

This rodent was first found in the State of Ohio, at Nashport, Licking County, and was described anonymously, but not named, by J. W. Foster, in the American Journal of Science and Arts for 1837, with figures, and subsequently named by him in the 2d Report on the Geology of Ohio, in 1838. It was again found at Clyde, Wayne County, New York, and was described and figured by Wyman in the Proceedings of the Boston Society of Natural History, in 1846. This discovery embraced the right ramus and the entire skull. In the University Museum are perfect plaster casts of these specimens, the original of which are in the museum of Geneva College. The remains of the same animal (ramus of the lower jaw) have been found also at Memphis, Tenn., which were described by Wyman in the Am. Jour. Sci. and Arts for 1850, vol. X, and in the third volume of the Proc. Bos. Soc. (1850); also by Agassiz in Proc. Am. Assc. Adv. Sci. for 1851. Mr. J. Le Conte records its discovery at Shawneetown, Illinois, in the Proc. Phil. Acad. Nat. Sci., vol. VI, p. 53, and J. Leidy notes fragments of teeth from the Ashley River, South Carolina, and a skull near Charleston, Coles County, Ill. Wyman also mentions its discovery near Natchez, Mississippi, and in Louisiana, and A. Winchell records it in Michigan, in the American Naturalist for 1870. J. A. Allen reports it from Dallas, Dallas County, Texas, from the alluvial deposits of the Trinity River, associated with the

remains of an extinct horse and mastodon, in the Monograph on Rodentia (vol. XI) of the United States Geological Survey of the Territories, by F. V. Hayden. It seems, therefore, to have been extended over the whole of the United States east of the Mississippi from Minnesota to Louisiana, and into Texas, and to have been cotemporary with the mastodon, and hence with the mound builders. It was, however, quite different from the living beaver, and may not have been acquatic. No portions of the skeleton except the head and teeth have been discovered. Its size was about that of the common black bear, according to Mr. Allen, and it was wholly a vegetarian.

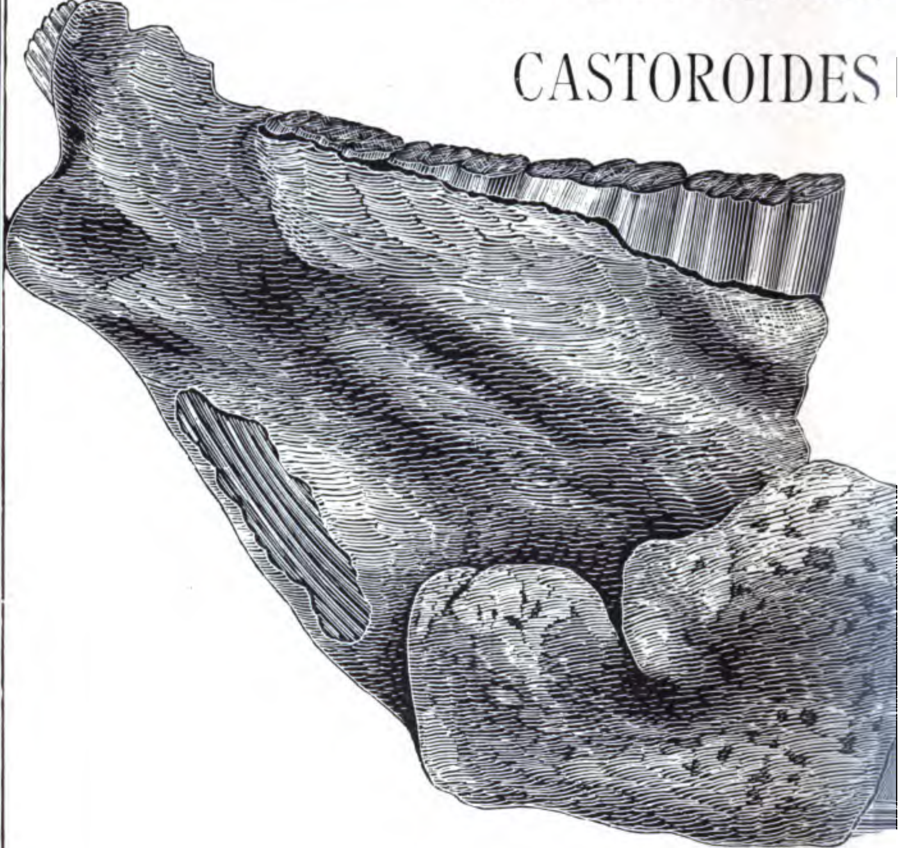
The specimens found at Minneapolis consist of the left ramus and the lower left incisor, the latter evidently broken from the former in being removed from the sand in which the whole was entombed. Their size indicates an animal somewhat larger than the specimen first found in Ohio and described by Foster, and also larger than that found in New York. It is, however, a little smaller than that described by Wyman from Memphis. The whole length of the specimen, when the parts are united, is 9½ inches, of which 5¼ inches consist of the projecting, uncovered incisor, a portion of the jaw being broken away on the under side. The condyle and coronoid process are wanting, and the sigmoid notch is also gone. On the under portion of the mandible the alveolar cavity of the incisor is broken into between the symphysis and the angular (?) process, disclosing the dark-brown enamel of the incisor. The angular process is about half an inch in length, directed obliquely inward and backward Its base extends antero-posteriorly an inch and a half. Its shape is that of a blunt rounded wedge, and its under surface is in a plane at right angles to the grinding surface of the molars. The four molars are all preserved perfectly. The first one, which rises a little more than half an inch in front, above the alveolar cavity, has four, obliquely transverse lamellæ, or flattened hollow plates, covered with enamel and cemented together, one after the other, by layers of *crusta petrosa*, which also seems to fill their interior. Within the alveolar cavity these plates, or sacks, at least in the fourth molar, are separate and free, and when this tooth is taken out their lower ends are open. The outer surfaces are finely striated perpendicularly, and crossed transversely by undulations of growth. The second and third molars have each three lamellæ, the first and last of which are obliquely transverse but parallel, while the second is more obliquely transverse and longer; nearly touching the interior angle of the third and the exterior angle of the first. The lamellæ all cross the mandible from within obliquely outward and forward. The second and third molars are of nearly the same size and shape, but they rise less above the alveolar cavity. They are sunk deep within the mandible, along the outside of the incisor. The enamel ridges on the grinding surfaces form a broad letter S. In the fourth molar the dentinal plates are three in number and more nearly parallel, and less oblique to the general direction of the grinding surface. These plates terminate on the upper surface of the incisor, which passes below, or along the inside of the bases of all of the molars. The symphysis of the mandible, where it united with the other ramus, is three inches long, there being a thickening of the bone and a downward process on the under side of the ramus where the incisor in use would most need a powerful fulcrum. The greatest diameter of the incisor, where broken, is one inch.

Its section is sub-triangular, the outer and lower surfaces being rounded, while the upper and inner surfaces are flat or slightly concave. The exterior curved surface is grooved longitudinally, with 18-20 grooves, which are about twice as wide as the ridges they separate. They are unequally distant, being more close on the lower side than on the outside. The inside and upper side are not thus grooved, but they show fine transverse waving undulations of growth, which also are sometimes visible crossing the grooves and ridges of the exterior surface. At the extremity, which seems to have run nearly to a point (now broken off) rather than to an edge, the enamel is worn away by use on the upper side about an inch from the end. There is a large duct or canal entering the ramus about an inch back of and above the fourth molar, which, passing the fourth molar without bifurcation, descends obliquely over the incisor outwardly, and passes below the third molar. The grinding surface of the molars is concave in the direction of its length, as in other specimens that have been described. Its length is three inches. Our specimen thus compares with others in the length of the grinding surface of the molars:

| | | |
|---|---|---|
| The Clyde specimen............................ | 2.7½ | inches. |
| The Nashport specimen......................... | 2.8 | " |
| The Memphis specimen.......................... | 3.1 | " |
| The Minneapolis specimen....... ............... | 3.0 | " |

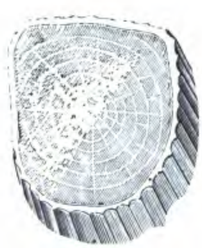
Prof. A. J. Allen regards the Castoroides so constituting the type of a distinct and hitherto unrecognized family (*Castoroididæ*) and separates it entirely from the *Castoridæ*. In the same group he inclines to include the Amblyrhiza and Loxomylus, described by Prof. Cope, from the bone caverns of Anguilla Island, West Indies. This rodent, he says, "presents a singular combination of characters, allying it, on the one hand, to the beaver, and on the other, to the chinchillas and viscachas, and also to the muskrat, but which at the same time separate it widely from either group."

# CASTOROIDES



*E*

*A*

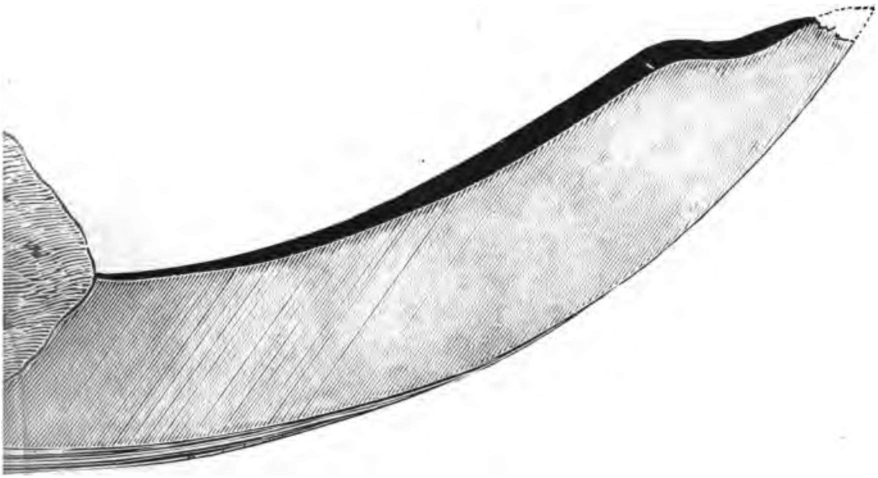


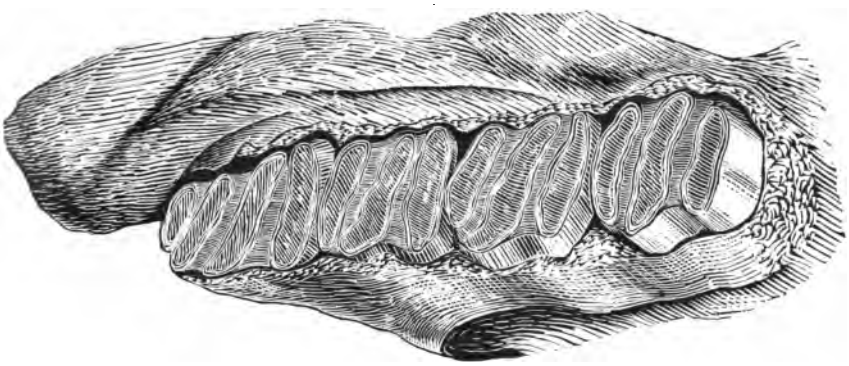
*C*

*B*

# OHIOENSIS, Foster.

*A. View of the fourth Molar from below.*
*B. Side view of the fourth Molar.*
*C. Section of the left Incisor.*
*D. Grinding surface of the Molars.*
*E. The left Ramus.*





*D*

# INDEX TO THE GEOLOGICAL REPORT.

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## ERRATA.

On page 12, 18th and 35th lines from the bottom, for *shine* read slime.
On page 19, 7th line from the bottom, for *pleocroic* read pleochroic.
On page 28, 10th line from the top, for *from* read four.
On page 134, 13th line from the top, after *takes* strike out the comma.
On page 136, 1st line, for *quartzytic* read quartzitic.
On page 143, 5th line from the top, for *pumiceusus* read pumiceus.
On page I43, 16th line from the top, for *memoralis* read nemoralis.
On page 174, 7th line from the top, for *this* read their.
On page 183, 8th line from the bottom, for *so* read as.